Materials & Methods

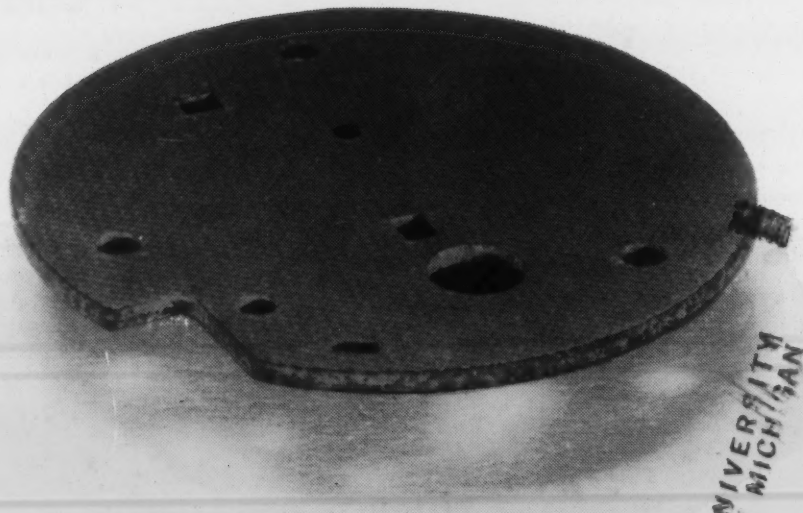
Selection & use of

metals, nonmetallics, parts, finishes,

in product design & manufacture

Selecting Plastics Laminates for Industrial Use—M & M Manual

February 1957



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Could Beryllium Be a Structural Material?

Short-Run Plastics Parts

Silicone Coatings for Metal Products

Fused Silica

Close Tolerance Wrought Iron Tubing

Complete Contents—page 1

PRICE FIFTY CENTS

Bob Rossi, Chief Engineer, tells
Roy Johnson, Plant Manager

"We switched to Formbrite —and saved 12 cents apiece!"

.032" gage 70-30 Formbrite is used for this 4½" diameter rearview mirror head shown full size. Strip is 5 13/32" wide supplied in heavy coils for long press runs. Copper, nickel and chromium plating on a solid brass base provides a bright, rustless, long-lasting outdoor finish.

Peerless Rearview Mirrors. "Flight-Wing," below, and the newer "Director" model, left. Housings and mounts are chromium-plated zinc-base die castings.

This easy-to-polish, superfine-grain drawing bras has been slashing finishing costs in plant after plant on all kinds of jobs. Now Peerless Accessories Co. of Mount Holly, N. J., reports:

"To our line of lighting and safety automotive accessories, we've recently added two rearview mirror assemblies. We had been using regular drawing brass for the dished head until your representative persuaded us to try Formbrite. Here are the results, based on a very careful cost study:

Finishing procedure using regular drawing brass	Present procedure using Formbrite®
1) Grease grinding or "cutting"	Not necessary with Formbrite
2) Buffing	Light buff
3) Copper strike	Copper strike
4) Nickel plate (.00045")	Bright nickel plate (.0003")*
5) Buffing nickel	Not necessary
6) Chromium plate	Chromium plate
Cost 27¢ each	**Cost 15¢ each**

"That's a saving of 12 cents apiece. Multiply it by 3,000 to 4,000 a day and it becomes important money.

*Formbrite's superfine grain made possible a lighter but equally serviceable plate of *bright* nickel

Surprisingly, Formbrite doesn't cost a penny more. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you make a better product at lower cost. Write for Publication B-39. Better yet, ask us about a sample lot. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

Formbrite FINE-GRAIN DRAWING BRASS

an ANACONDA® product

made by The American Brass Company

For more information, turn to Reader Service Card, Circle No. 420

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Materials & Methods is indexed regularly in the Engineering Index and the Industrial Arts Index

Materials & Methods®

Selection & use of metals, nonmetallics, parts, finishes in product design & manufacture

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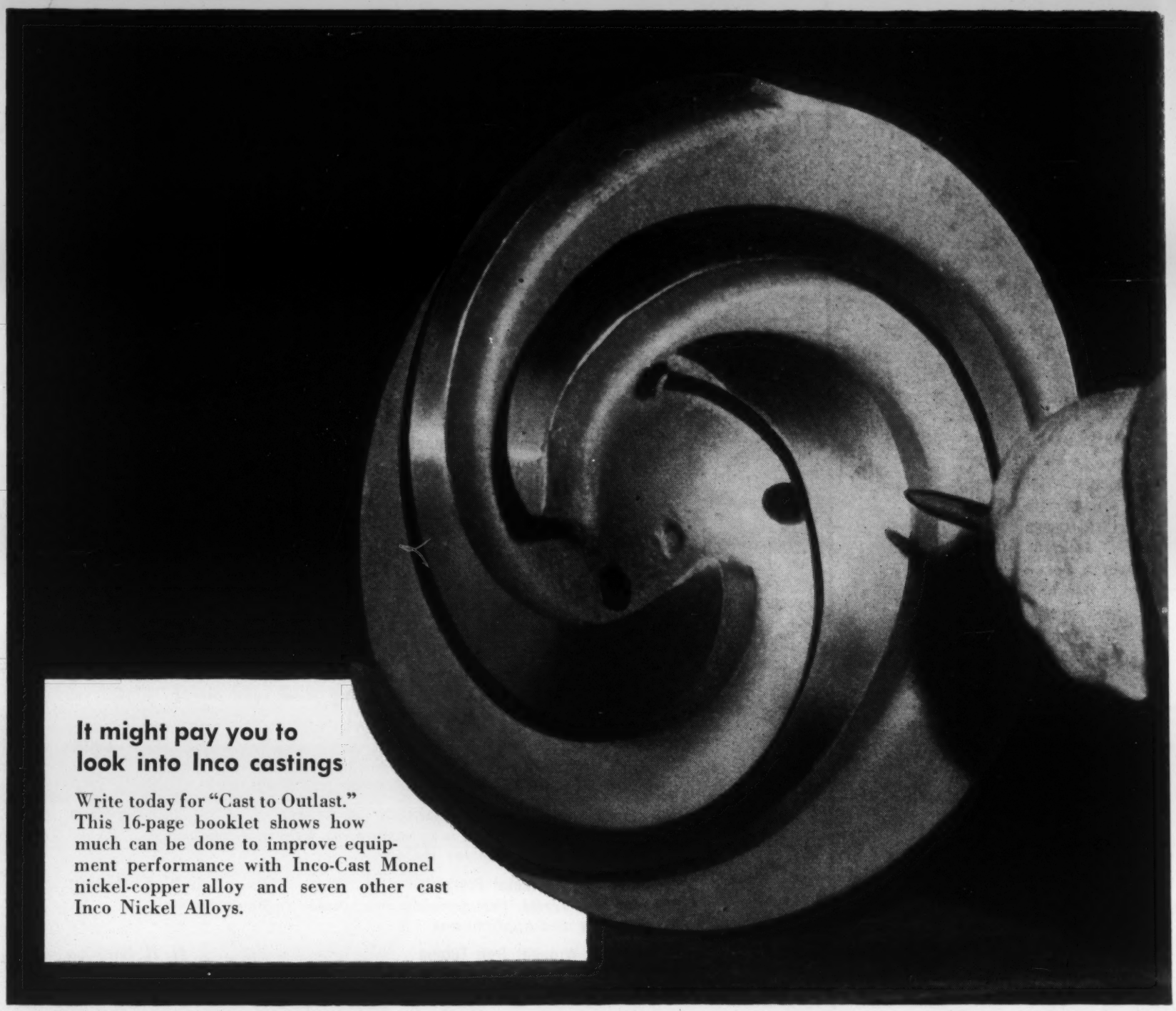

Heart of a Dowell "chemical brush" —an Inco-cast Monel impeller

Here's the heart of a cleaning unit that pumps corrosives at high velocities through chemical equipment. The unit is made by Dowell Incorporated, of Tulsa.

Dowell engineers use this impeller of Inco-Cast Monel* nickel-copper alloy to pump cleaning solvents. Composed largely of hydrochloric acid, these solvents are pumped from special tank trucks, into plant piping and equipment, to dissolve troublesome scale and deposits.

To protect the pipe and equipment from this dilute hydrochloric, Dowell strictly controls temperatures and exposure time. And they use specific inhibitors to prevent corrosion.

But how would Dowell protect their pumps? The high velocities would throw off inhibitors and coatings.

After testing scores of materials, Dowell engineers decided on Inco-Cast impellers of Monel nickel-copper alloy. They selected this alloy because it resists attack by dilute hydrochloric acid. And by caustic solutions and compounds containing fluorine, which are sometimes added to dissolve silicate scale.

Stuffing box seals and shaft sleeves are also made of this corrosion-resisting nickel-copper alloy. Likewise, pins for acid tanks. And usually, the flange and nipple on field tanks are Monel nickel-copper alloy, too.

Whenever you are confronted with destructive service conditions, be sure to investigate the advantages Inco-Cast alloys can provide. One of these may be the answer to your difficulty.

The International Nickel Company, Inc.
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INCO TRADE MARK **Castings** ● ● ● *Sand, Centrifugal and Precision*

For more information, turn to Reader Service Card, Circle No. 518

What's new IN MATERIALS

...AT A GLANCE

STRIPS OF HIGH CARBON STEEL, having a thickness tolerance of ±0.00025 in., are possible with a new process. The 0.028-0.033 in. thick cold rolled strips remain sufficiently ductile to permit cold forming into intricate shapes, and they are presently being fabricated into piston rings.

TRANSPARENT SILICONE RUBBER acts as an interlayer in windshield glass for supersonic aircraft. Laminated windshields made with silicone interlayers retain full strength and clarity at temperatures ranging from -65 to 350 F. At temperatures up to 160 F the silicone laminated windshields have somewhat less shatter resistance than conventional laminates, but the strength of the conventional butyral interlayer falls off so sharply above 160 F that at 200 F the new silicone is more than twice as strong.

A NEW METHOD OF PRODUCING FLUSH PRINTED CIRCUITS is claimed to: 1) cut costs, 2) permit tolerances of ±0.0001 in. on flatness of circuit faces, 3) provide a wide choice of base laminates, and 4) allow a high degree of circuit intricacy. (See page 137 for more information.)

ZINC-RICH PAINT, developed in England and now in commercial use in this country, promises to give effective cathodic protection to new or rusty iron and steel surfaces. The paint is said to prevent corrosion of scratch marks and is also said to be resistant to rust creep. It protects metals used in salt and fresh water service and in ordinary atmospheric service.

ENAMELED, ALUMINUM-CLAD COPPER WIRE promises to reduce wire size and raise the efficiency of electrical equipment by allowing it to operate longer at higher temperatures. The thin coating (0.0025 in.) of aluminum, together with the insulating enamel, provides a wire having good electrical conductivity, heat resistance and oxidation resistance. The wire may find application in the electrical systems of guided missiles, jet planes and industrial ovens.

ALUMINUM-TIN BEARINGS SHOWED NO APPRECIABLE WEAR or deterioration after 60,000 miles of pounding and grinding on a Rome streetcar. They were run as axle bearings against shafts of two different hardnesses. The bearings of surfaces showed some scoring due to foreign matter, but no trace of seizing was found.

What's new IN MATERIALS

A MODIFIED, NICKEL-BASE ALLOY for high temperature service is presently being evaluated in gas turbine engines. Containing chromium, molybdenum, iron and boron, with aluminum and titanium as hardening agents, the material can meet a specification calling for 120 hr minimum life at 28,000 psi and 1600 F. The new alloy, available as an investment casting, is made only by vacuum melting at present. (More details next month.)

EVALUATING THE USEFULNESS AND ENDURANCE of rubber, plastics and textile products at temperatures of 1000 F is now possible with a new device. Specimens are aged in individual, isolated compartments in an electrically heated stainless steel block.

POWERFUL PERMANENT MAGNETS have been made on a laboratory scale by embedding submicroscopic iron particles in plastics, glass, rubber or metal. The tiny particles, possessing the same chemical composition and crystal structure as ordinary iron, have a resistance to demagnetization 100,000 times greater than ordinary iron. Since size, shape and material are practically unlimited, the new magnets offer infinite possibilities in the design of electrical and other equipment using permanent magnets. (More details next month.)

A NEW PERMANENT MAGNET ALLOY is also available. It is composed of aluminum, cobalt, copper, iron and columbium. The columbium addition provides a very stable alloy with high magnetic values. The material can be fabricated by casting or grinding.

STILL ANOTHER MAGNETIC MATERIAL, A FLAKE METAL ALLOY, has been developed for use as a magnetic core in communications equipment. The material, composed of iron, silicon and aluminum, is inexpensive and is relatively simple to manufacture. The outgrowth of a flake form alloy created 20 years ago by the Japanese, it is competitive in price with costly nickel alloys.

NEW SELF-EXPANDING PLASTICS FOAM consists of polystyrene beads and an exothermic type thermosetting resin. Heat developed during cure of the thermoset expands the beads to desired densities, and the bead expansion drives the resin out to form a protective coating on the finished part. Most success to date has been with an epoxy system.

A READY-CURED SYNTHETIC RUBBER LINING MATERIAL with good over-all chemical resistance makes it unnecessary to cure tank linings after application. Applied cost per square foot is appreciably lower than that of natural rubber and other materials now in use. The lining material is available as part of a package consisting of primers, adhesives and putties.

Turn to p 147 for more "What's New in Materials."

MATERIALS BRIEFS

How's the Fit?

A suit that resists fuming nitric acid and temperatures from —80 to 1000 F is made by coating a glass fabric, backed with silicone rubber sponge, with a thin coating of polychlorotrifluoroethylene pigmented with aluminum.

Fixing Up a Moon

A variety of protective coatings will be used on the magnesium satellite housing for Project Vanguard. The coatings are gold, copper, zinc, silver and nickel.

Shock-Proof Undies?

Three new products developed in France are said to prevent the formation of electrostatic charges on synthetic textile fibers. The products are suitable for synthetic fibers of the polyamide, polyester and polyacrylonitrile varieties.

Best for Wurst

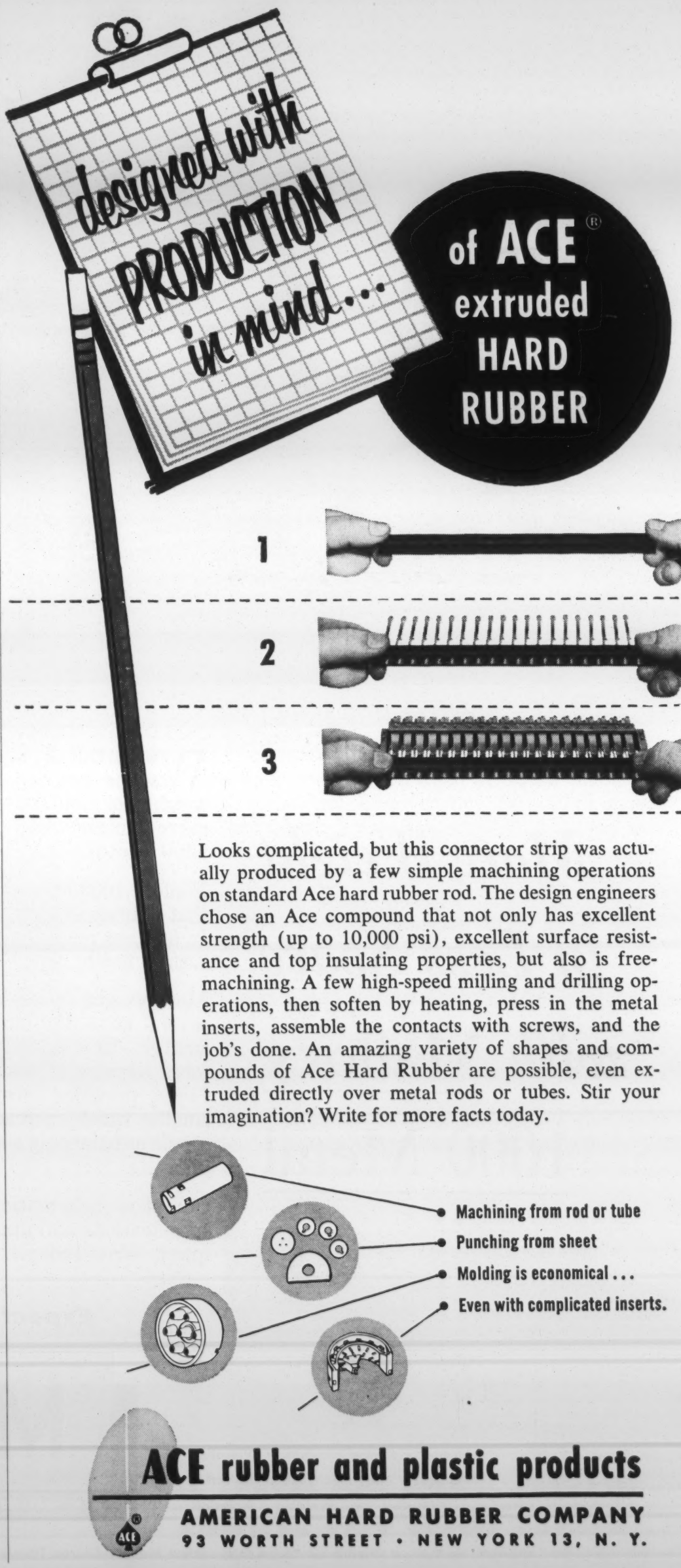
A two layer vinyl casing that prevents ink from coming into contact with liverwurst, and also prevents moisture loss from the wurst, won first prize in the 1956 National Flexible Packaging Competition.

Button, Button

Approximately 12,000,000 lb of polyester resin are used annually in making shirt buttons.

Waterproof Roads

A water-repelling silicone resin used on concrete highways reduces cracking and splintering caused by extreme winter temperatures and the salt solutions used in ice removal.



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More Weight in Less Space with Mallory 1000 Metal

WHATEVER the nature of your assembly—gyroscope rotors, counterbalances, balancing weights, or similar mass components—you can get more weight into less space with Mallory 1000 Metal.

Mallory 1000 has a density of 16.96 gm/cc—twice that of brass or steel, and is far stronger than lead! It features ready machineability—even to a high surface finish.

More weight in less space means real savings in several ways. For example, housings can be made smaller—thus overall assemblies become smaller for a savings in cost and weight. Mallory 1000 Metal provides exceptionally high inertia in a smaller space, increasing the sensitivity of gyroscopic or balancing action, yet reducing the overall unit size.

Complete information on Mallory 1000 Metal specifications and applications may be had on request. Write today.

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For information on titanium developments, contact Mallory-Sharon Titanium Corp., Niles, Ohio

For more information, turn to Reader Service Card, Circle No. 368

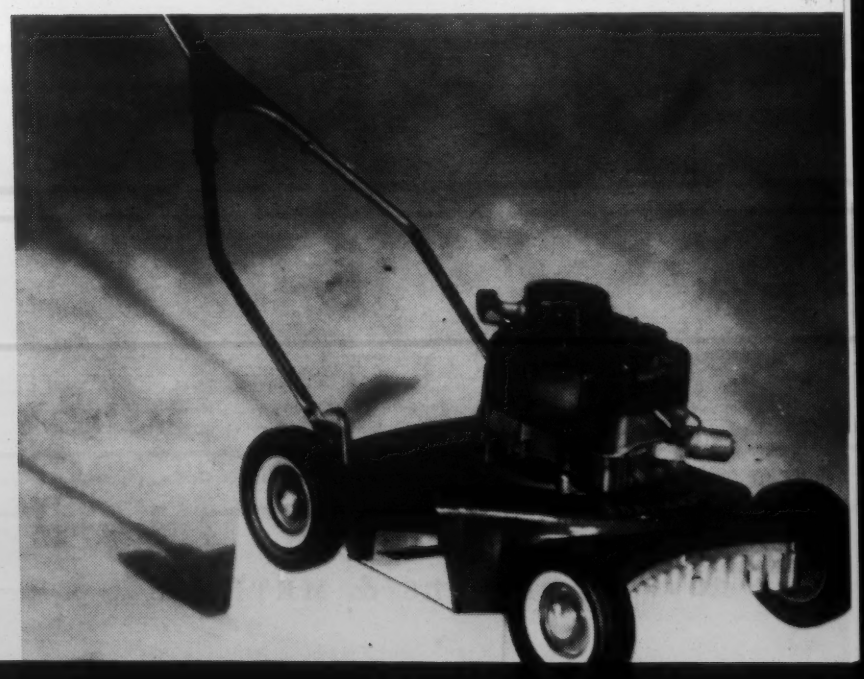
MATERIALS AT WORK

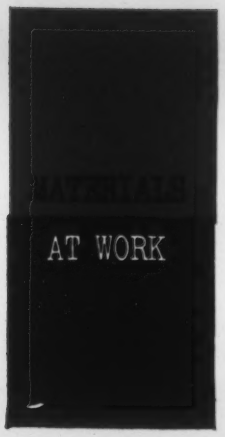
New and interesting applications of engineering materials

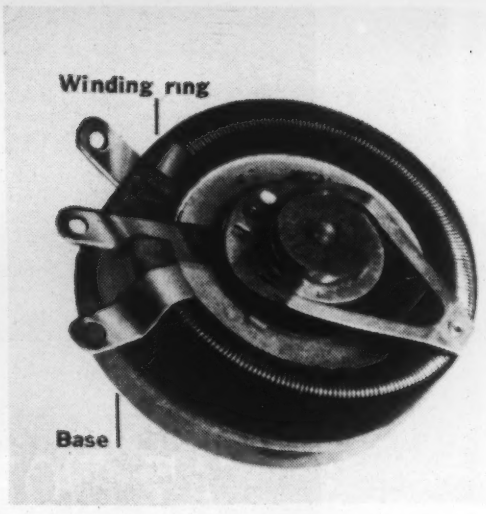
Lawnmower 'wheels' along on nylon and styrene

By combining the abrasion resistance and self-lubricating qualities of nylon with the strength and durability of extra-high-impact polystyrene, Sears, Roebuck & Co. has been able to produce a lawnmower wheel claimed to be stronger, quieter and longer-wearing than conventional metal wheels.

The wheel is composed of a nylon center bearing and frame with spokes molded of polystyrene (see above). Because the nylon bearing is a tube with walls only 1/16 in. thick, it is difficult to hammer or press it into the center of the wheel, as metal bearings are often inserted. However, the difference in melting points of the two materials makes it possible to injection mold polystyrene around the previously formed nylon bearing to produce an integrally formed piece. Both plastics are made by Catalin Corp. of America.

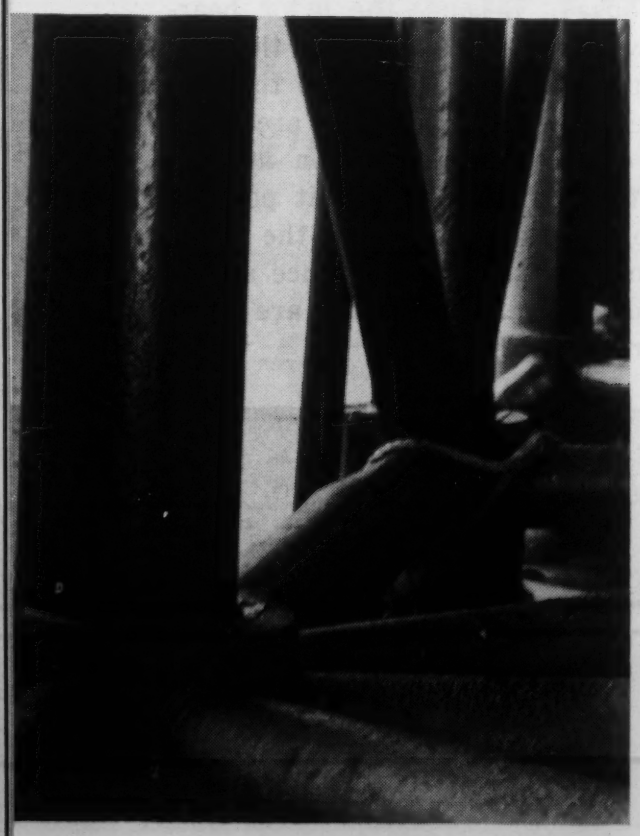






Components *of ring rheostat made from glass-bonded mica include winding ring, base and hub.*

Vinyl paint protects oil drilling rigs

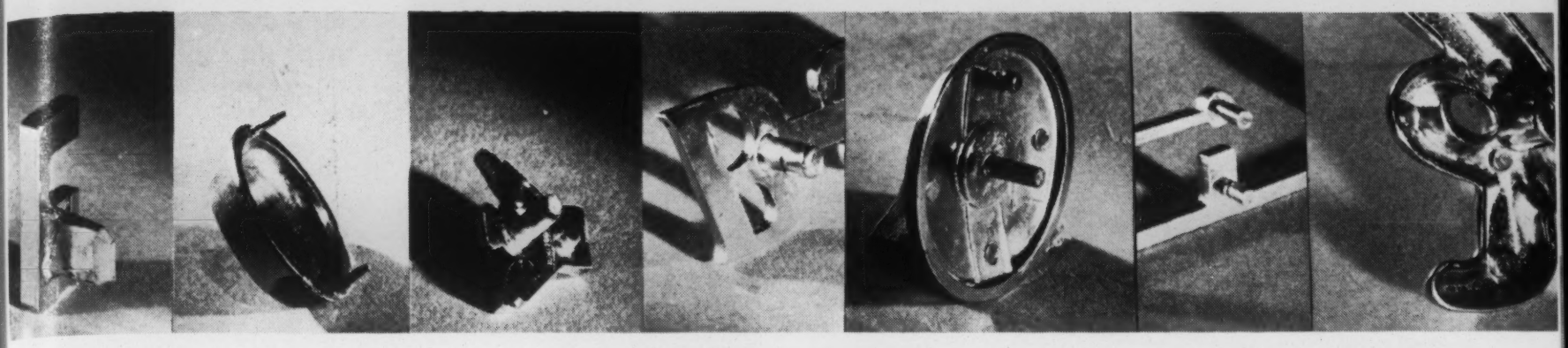


A six coat vinyl paint system gives corrosion protection to offshore oil drilling structures in the Gulf of Mexico. The coating is about 0.006 in. thick and is designed to endure not only weather, but also constant exposure to sea water, residual oil, mud, sand, and shale.

The six coat system, developed by Socony Mobil Oil Products Co. and based on Bakelite resins, is composed of four primary and two finish coats. A typical structure requires about 1200 gal of paint.

Glass-bonded mica used in ring rheostats

A precision molded glass-bonded mica is being used in ring rheostats manufactured by Ward Leonard Electric Co. The material, supplied by Mycalex Corp., is said to be the first ceramic-type insulating material to successfully fulfill all requirements of the U.S. Navy HI shock test specified for shipboard components. It was selected for the rheostats because of its high temperature resistance, its dimensional stability, its favorable thermal coefficient of expansion, its good electrical properties, and the ease with which structural supports, terminals and collector rings could be molded in.

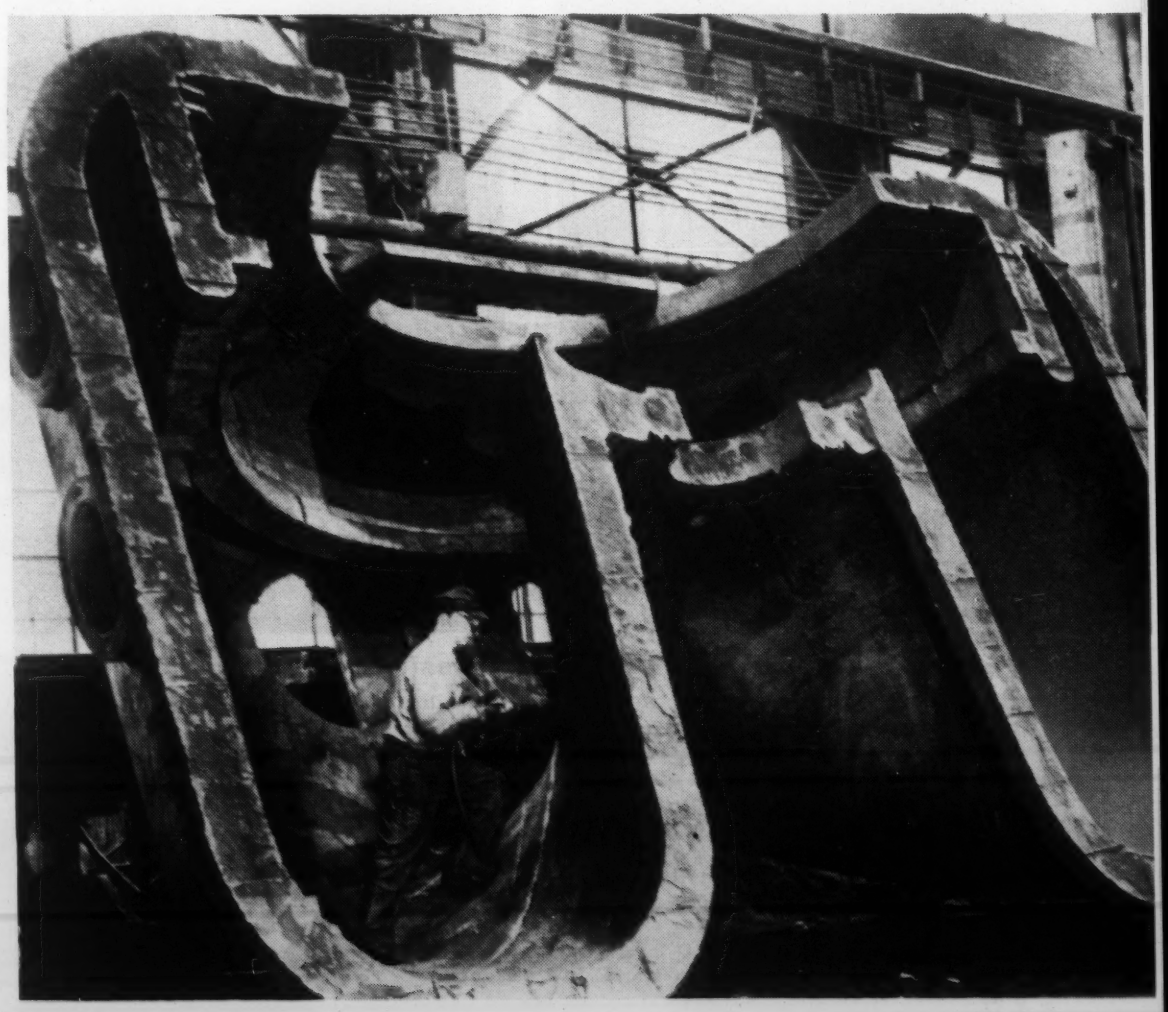


Zinc die castings easy to assemble

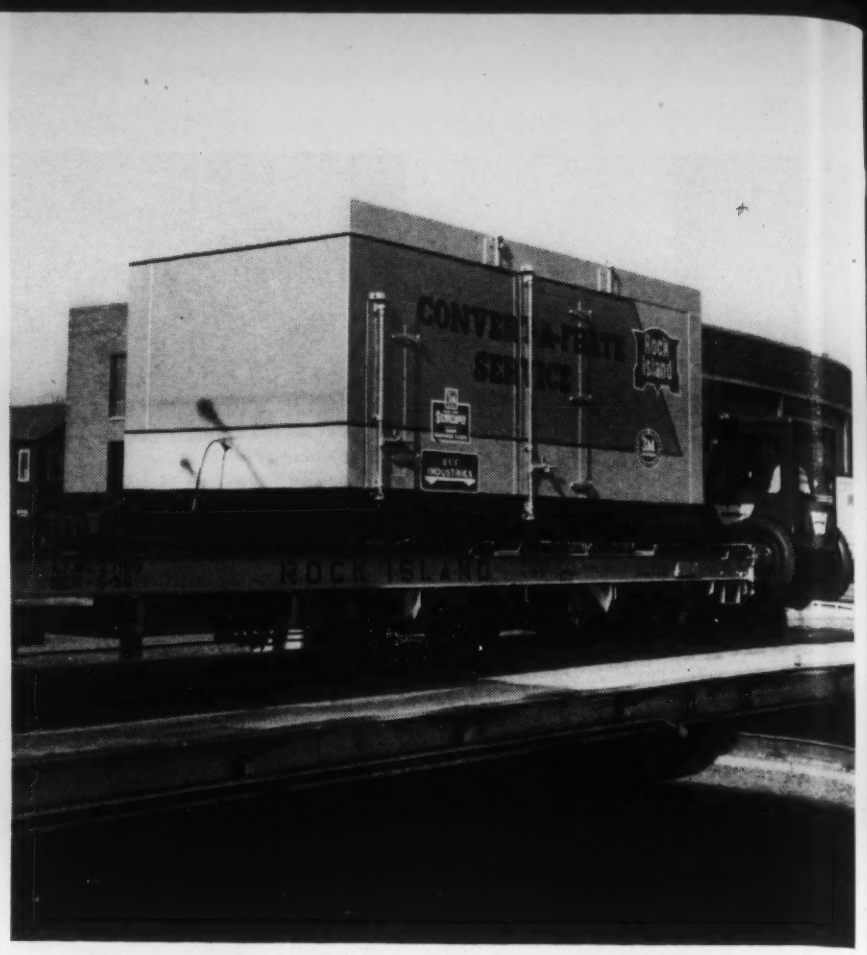
Integrally cast projections make these familiar die cast zinc insignia easy to assemble. The studs, shanks or bosses (see close-up views) may be of zinc or they may be threaded inserts. Speed nuts or clips are most widely used for assembly.

Casting weighs 100,000 plus

This iron casting only took 3½ min to pour, but 15 men worked 20 weeks to prepare the pit and to mold, cast, clean, cool and ship the 101,040-lb casting. It will serve as the upper exhaust hood for a 171,000-kw steam turbine. The largest casting ever produced by General Electric Co., it is 14 ft high, 22 ft wide, and 10 ft deep.

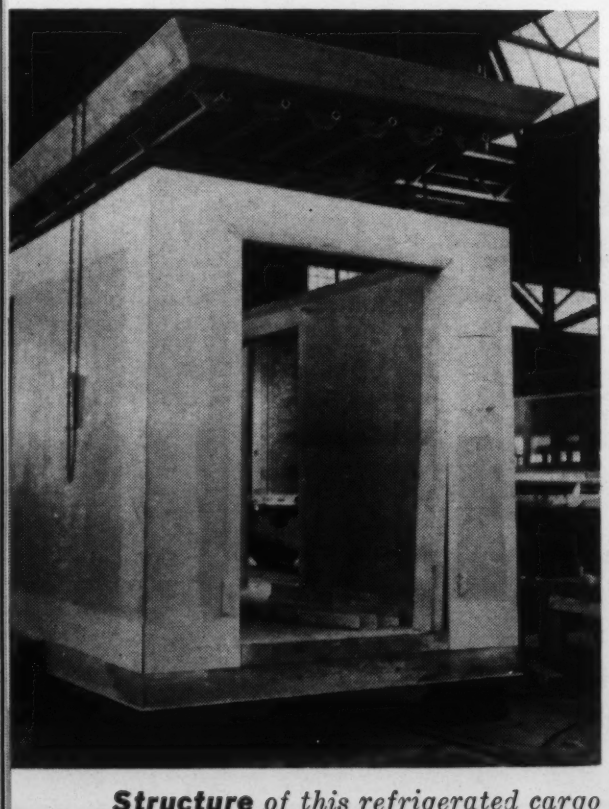


Refrigerated unit *carrying 14,000 lb of meat is lifted from flatbed trailer . . .*

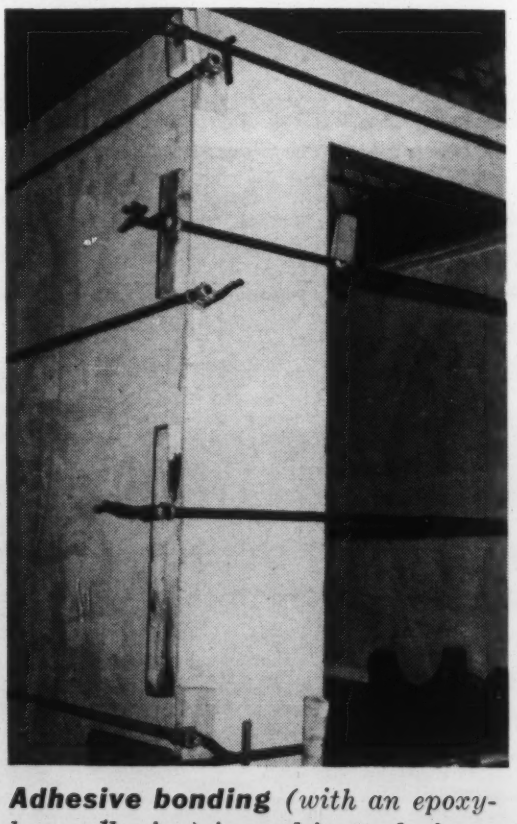


. . . and placed on flatcar to complete an uninterrupted trip from shipper to receiver.

Glass-epoxy laminate for 'convertible' truck



Structure *of this refrigerated cargo unit is composed of single section panel sides and roof made of 5¾-in. thick flat-grain balsa cores faced with ⅛-in. thick isotropic glass-reinforced epoxy laminates. The floor is a 2¾-in. flat-grain balsa core surfaced on the top with plywood and on the bottom with ¼-in. glass-epoxy. The complete unit measures 17 x 8 x 8 ft.*

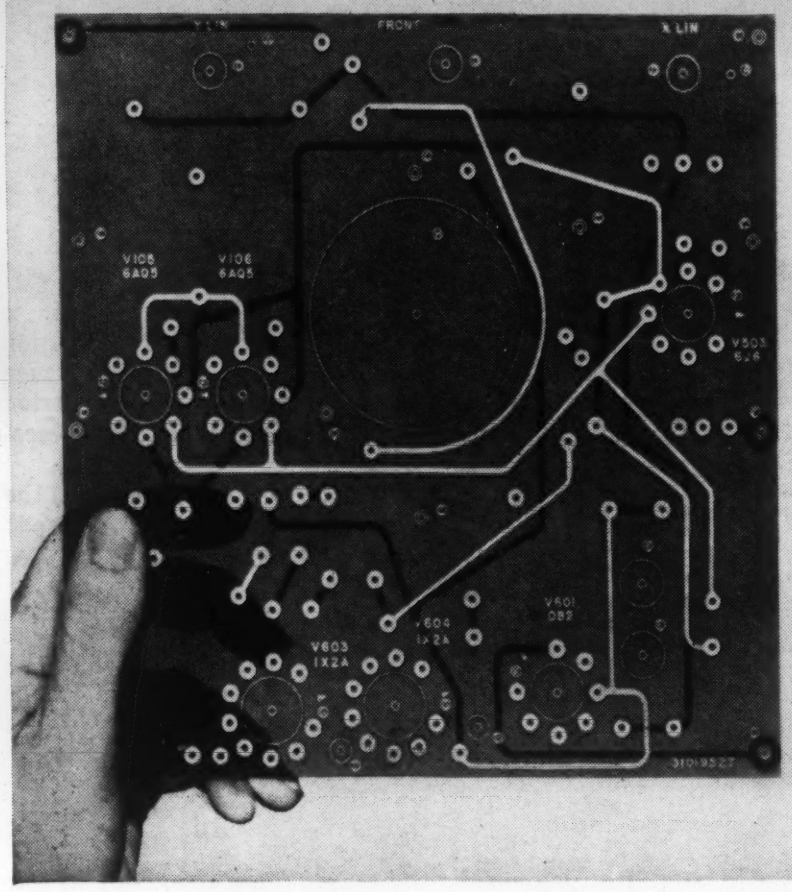


Adhesive bonding *(with an epoxy-base adhesive) is used instead of mechanical fasteners. This method of joining insures a high degree of thermal insulation, as well as a continuous plastics surface which is easy to keep clean.*

The use of reinforced plastics as a structural material has been given added impetus with the successful completion of a new type of refrigerated cargo unit. The lightweight unit, composed of glass-reinforced epoxy sandwich-type panels, can be quickly converted from railway flatcar to truck-hauled flatbed trailer and back again with the aid of only a fork-lift truck. The quick conversion eliminates time lags and additional carrying costs normally involved in switching and routing layovers of entire railway cars. The material is ideally suited to the application in that it offers a combination of strength, light weight, nonconductivity and corrosion resistance.

Below . . . No problem with electrical properties when your printed circuits are based on XXXP laminates made with RCI PLYOPHENS 5027 and 5036.

Photos courtesy of The Formica Company



Above . . . You cut treating machine time when filler sheets for high pressure decorative laminates are made with RCI PLYOPHEN 5573.

Left . . . You reduce stack losses when you use PLYOPHEN 328 for binding fibrous glass or mineral wool into insulation batts. And P-328's low alkalinity definitely improves the water resistance of the insulation.

fast cures and sure results...

when you use RCI liquid phenolic resins . . . *job-designed* for your laminating and bonding needs.

Reichhold has a PLYOPHEN liquid phenolic tailored to your exact need . . . whether the resin is going into the manufacture of printed circuits, into a binder for fibrous glass or mineral wool insulation, into filler sheets for decorative laminates, or any one of scores of other products.

PLYOPHENS are *job-designed* to assure fast production *and* uniform results. RCI controls quality all the way . . . right from the beginning, by producing its own phenol and formaldehyde.

Write us the details of your phenolic resin application and ask for a *sample* of the RCI liquid phenolic that will do the job best. Then try it out and see if you don't get superior results.

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MEETING DESIGN NEEDS

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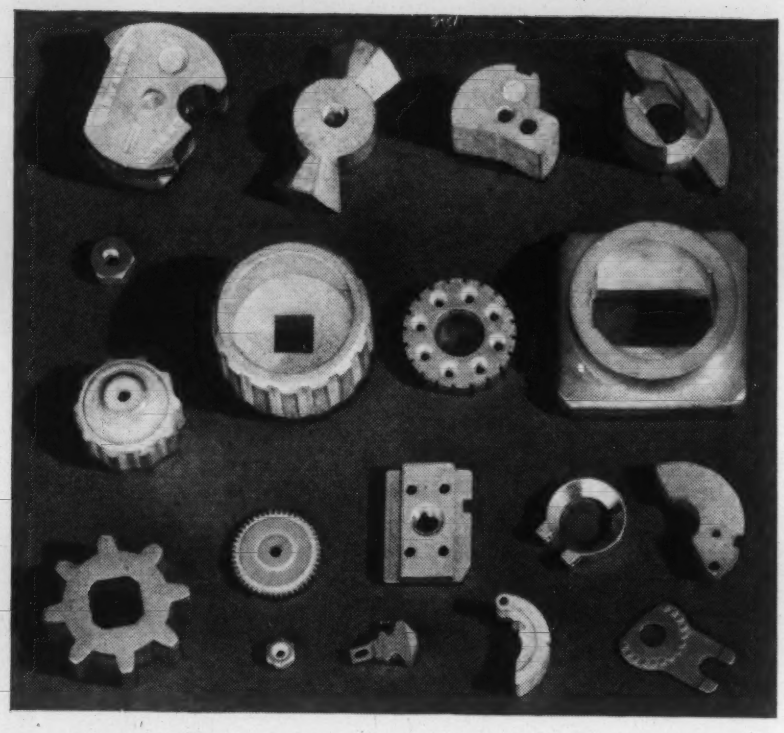
BRASS AND NICKEL SILVER POWDERED METAL PARTS

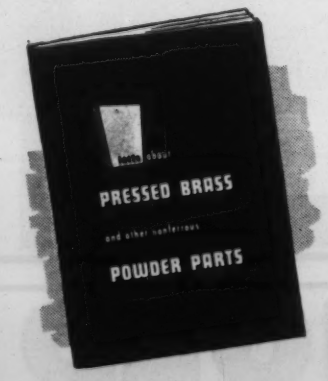


Very substantial savings are being realized by manufacturers who have turned to powder metallurgy for structural and functional parts. In each case, use of the metal powder process was justified by cost comparison with a previous method of meeting design needs.

Even greater economies could have been achieved by these manufacturers if sinterings had been used initially. Immediate savings over other possible methods are much greater when the high cost of original tooling and the cost of conversion can be avoided.

When designing a new product, first investigate the use of BRASS AND OTHER NONFERROUS POWDER PARTS. Consult a Powdered Metal Fabricator and take advantage of his experience in cost-saving production methods.

How Can BRASS AND NICKEL SILVER POWDER PARTS Meet Your Design Needs?



For detailed information on the design, properties, production and application of brass and other nonferrous powder parts you should have a copy of our manual. It will give you 20 case histories of brass and nickel silver powder structural parts to assist in evaluating this means of production in terms of *your* particular needs.

SEND FOR YOUR COPY

THE NEW JERSEY ZINC COMPANY
160 Front Street New York 38, N. Y.

HORSE HEAD PRODUCTS

For more information, turn to Reader Service Card, Circle No. 398

Materials certification agency

To the Editor:

The article entitled "Materials Certification Plan Gets Mixed Reception" (Sept '56, p 13) was greatly appreciated. It is through such discussion that opinions can be aired, and corrected if necessary.

On the question relating to the need for the agency to certify aircraft items, the poll showed:

	In favor	Not in favor	Waive
Materials engineers	29	10	4
Materials suppliers	30	20	13

On the question relating to which fields the agency should cover, the poll showed:

	In favor	Not in favor	Waive
Materials	72	19	10
Hardware	42	10	43
Equipment	29	16	49

It is clear that need exists for this agency in the materials field, and possibly in the hardware field. The first opinion quoted in your article stated: "Testing procedures, materials and components are not sufficiently standardized in the aircraft industry to permit such an agency to be effective." It also expressed doubt that acceptance could be achieved, and indicated the inadvisability of such an agency operating between purchaser and supplier. I should like to point out that material standards *are* quite well fixed in the industry through the several material specification series, and it is upon this premise that the proposal was presented. On the second point, acceptance by both material users and producers is paramount, but it is not intended that the agency be in a position between supplier and user. Its existence should not affect the buyer-seller relationship except to provide the buyer with a list of qualified products that have met certain basic requirements. The agency would be in the position of an impartial third party.

The second opinion you quoted refers to the agency being answerable to the material suppliers rather than to the purchasers. This is a misinterpretation of the organization of the agency. The directors would be a group of key engineering people from all aeronautical interests, functioning as individuals. Policy control would be with the purchasers, not with the suppliers.

I appreciate this opportunity to present a further word of explanation, and welcome further comments from your readers.

CHARLES M. MILLER
Materials Engineer
Northrop Aircraft, Inc.

Mr. Miller proposed the establishment of a cooperative materials certification agency in the Apr '56

(continued on p 16)

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Letters to the Editor

issue of SAE Journal. *The* MATERIALS & METHODS *article to which Mr. Miller refers was a brief report of the results of an SAE poll conducted in the aircraft industry. The M&M article quoted some dissenting remarks; Mr. Miller's letter is published here to clarify any misconceptions that may have resulted.*

How low is high?

To the Editor:

I was somewhat startled by an item appearing on page 4 of your January issue. It referred to a new acetal resin as "A New High Temperature Plastic." As I understand it, this thermoplastic resin, developed by Du Pont, has a heat distortion temperature of about 212 F. If this be high temperature, in what class are the TAC-polyesters or, perish the thought, the silicones?

E. R. CUNNINGHAM
Long Island, N. Y.

Somewhere we dropped a "thermo". More information on this new high temperature thermoplastic will be found on page 153.

Wanted: fibre substitute

To the Editor:

We are interested in obtaining an inexpensive substitute material for vulcanized fibre. We punch small parts from this material for use in electrical wiring devices. . . .

A. M. SURDUT
Purchasing Agent
Cable Electric Products, Inc.
Providence 7, R. I.

It will probably be impossible to substitute a cheaper material without sacrificing vital physical and electrical properties. Some of the industrial plastics laminates might be investigated, but vulcanized fibre is probably less expensive. Perhaps some of our readers can help.

Continuous casting molds

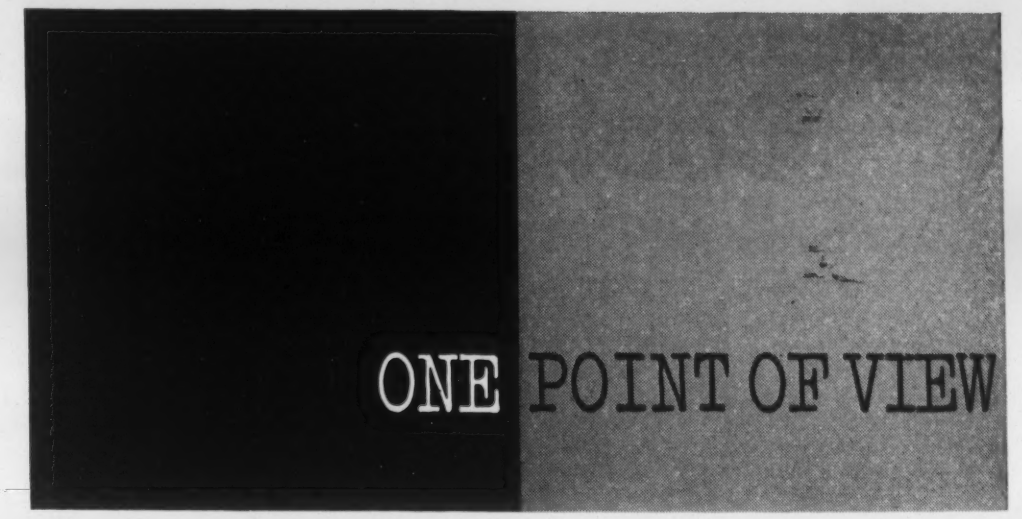
To the Editor:

Do you have any information concerning the use of ceramic molds for continuous casting?

I am a subscriber to your publication but do not recall having read anything on this subject. . . .

C. F. CARPENTER
Industrial Consultant
Allentown, Pa.

In our experience, molds for continuous casting have been made of water-cooled copper and graphite. For further information, try contacting Continuous Metalcast Corp., 40 Wall St., New York City. Such a development would not necessarily be covered by our magazine since we are concerned not with the production of materials but with selection and use.



Two metal powder associations would be one too many

By and large most of the trade associations in the engineering materials field are doing a good job. Not only are they aiding their own members by joining together to solve common problems, but their activities also benefit the users of materials. For example, some of the objectives of trade associations include the development of standards and uniform practices, the raising of the quality level of their products, the dissemination of technical information, and the sponsorship of research programs to develop new or improved materials.

Work together . . .

Because of these benefits to users of materials, we are naturally interested in the progress and health of trade associations. The events presently taking place in the powder metallurgy industry and its trade organization, the Metal Powder Association, have focused attention on a basic and controversial question that sooner or later confronts many trade associations in the materials producing industries. The question: is it a good thing for basic materials and equipment suppliers, custom fabricators, and in-plant or captive shops all to join together in the same trade association?

. . . or separately?

The general trend has been to form separate associations for the different interests within each field. In a number of cases this has resulted in duplication of effort, we feel, and occasionally in intramural sniping that has helped no one.

The history of the Metal Powder Association has been counter to this trend, and, as far as we know, the MPA's make-up is unique in the engineering materials field. Membership is open to basic powder producers, equipment suppliers, custom molders, in-plant shops and consultants. We believe that a liberal policy such as this is the most effective way of rapidly advancing a young industry. Therefore, we were concerned to learn that this established policy of MPA is being questioned by a number of custom fabricators who are moving to organize an independent trade association of metal powder parts fabricators.

One group more effective

We believe that the advantages of a combined association far outweigh any advantages that might result from having two organizations in the same industry. Standards, research and other technical programs, promotion, and educational projects are only a few of the activities that are common to the entire industry. To us it seems self-evident that such activities can be pursued more effectively at less cost by pooling the resources of all phases of an industry than by having each segment go it alone.

No conflict of interest

Also, it has always been our belief that custom fabricators and in-plant producers of parts gain more by cooperating with each other than by being mutually exclusive. We believe past experience has proved that growth of in-plant facilities means faster growth of the entire industry, and that this in turn means more business for the commercial shops.

For the above reasons we hope that all the different groups within the powder metallurgy field will continue to support the Metal Powder Association. A strong united organization will mean rapid growth of the entire industry and, at the same time, will benefit present and potential users of metal powder parts.

FEATURE ARTICLES

Could Beryllium Be Used

Lighter tension members plus . . . lighter buckling members . . .

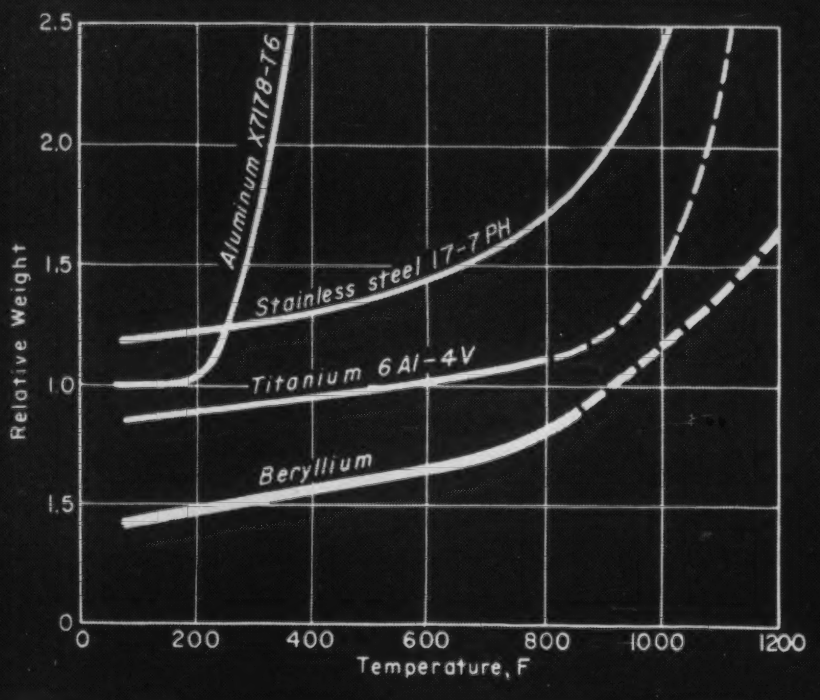


Fig 1 — *Relative weight of tension elements at various temperatures.*

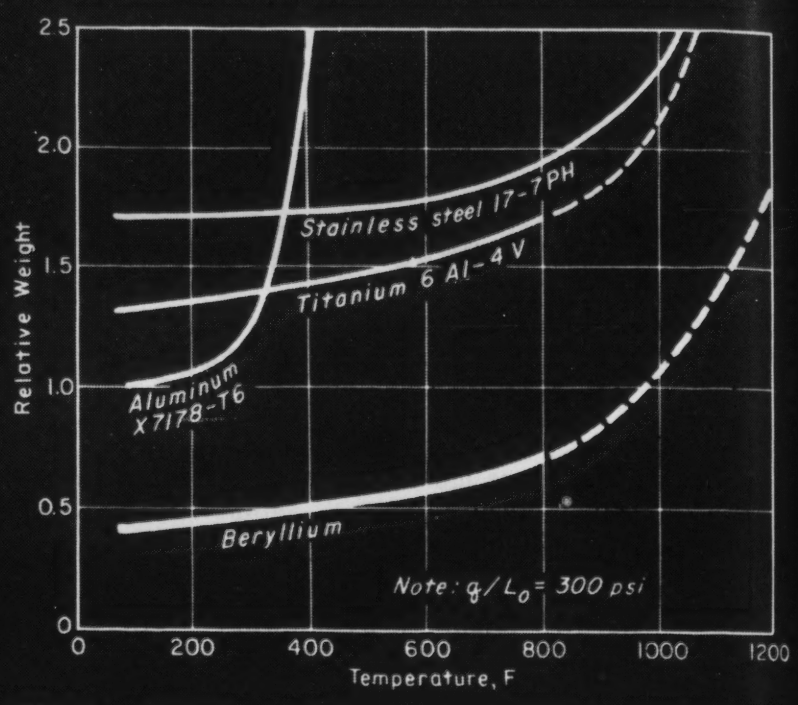


Fig 4 — *Relative weight of sheet-stiffener panels at various temperatures.*

A high stiffness-weight ratio makes it promising for aircraft if some way can be found to eliminate brittleness.

by George A. Hoffman, *Rand Corp.*

■ Beryllium has been suggested for aircraft structures at various times for the past 20 years. Sufficient data have now accumulated to permit a comprehensive structural evaluation and the results are highly significant. Beryllium aircraft structures would weigh less than half as much as aluminum structures, and similar weight savings in elevated temperature applications could be achieved if certain technical problems can be solved.

The structural value of a metal is determined by such factors as physical and mechanical properties, cost and availability. Most of beryllium's properties are uncertain; the figures given in the table (p 102) are quite tentative.

For example, although single values are given for tensile and yield strength, considerable variation is typical of the metal because of its sensitivity to the production method. Ductility, as indicated by elongation, is low. It is possible that material produced in the future will have increased strength properties; for that reason, figures given in the table

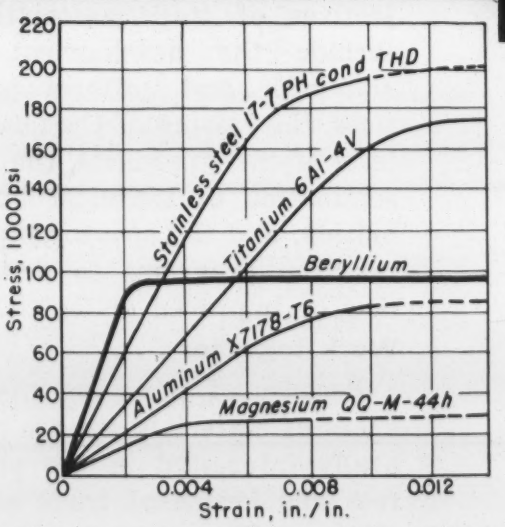


Fig 2 — *Compressive stress-strain curves at room temperature.*

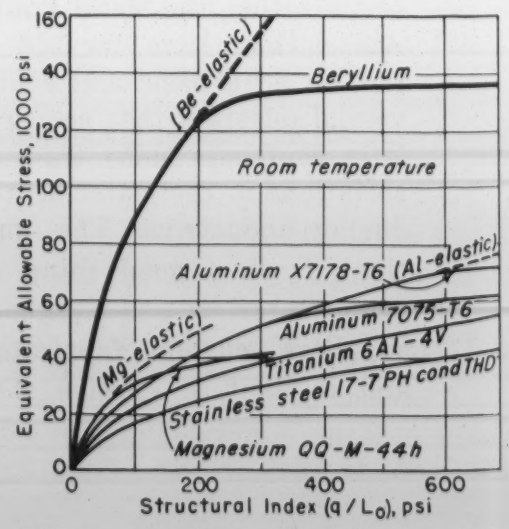


Fig 3—*Relative value of materials as sheet-stiffener panels.*

As a Structural Material?

would mean a lighter plane . . . at lower cost

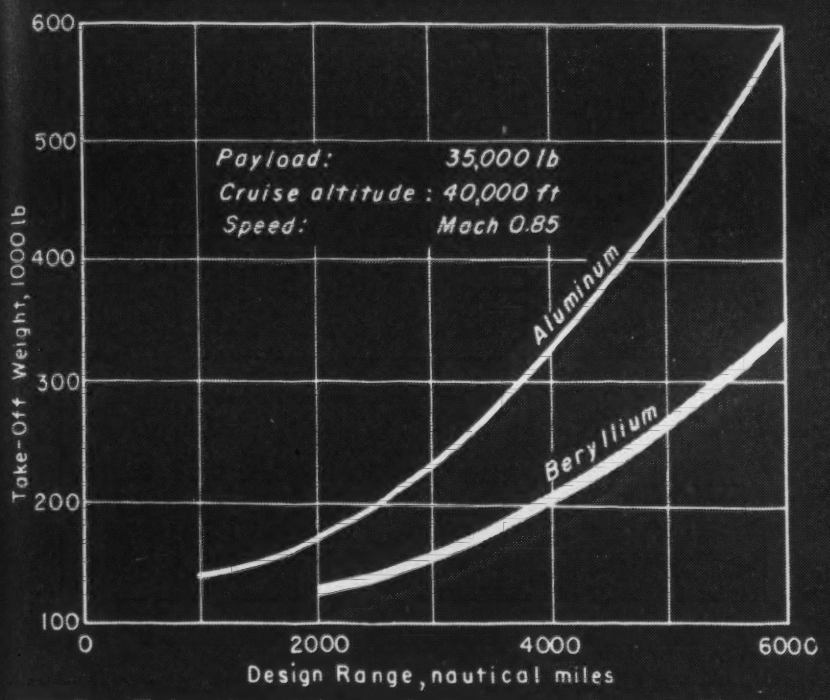


Fig 5 – *Take-off weight vs design range for beryllium and aluminum transports.*

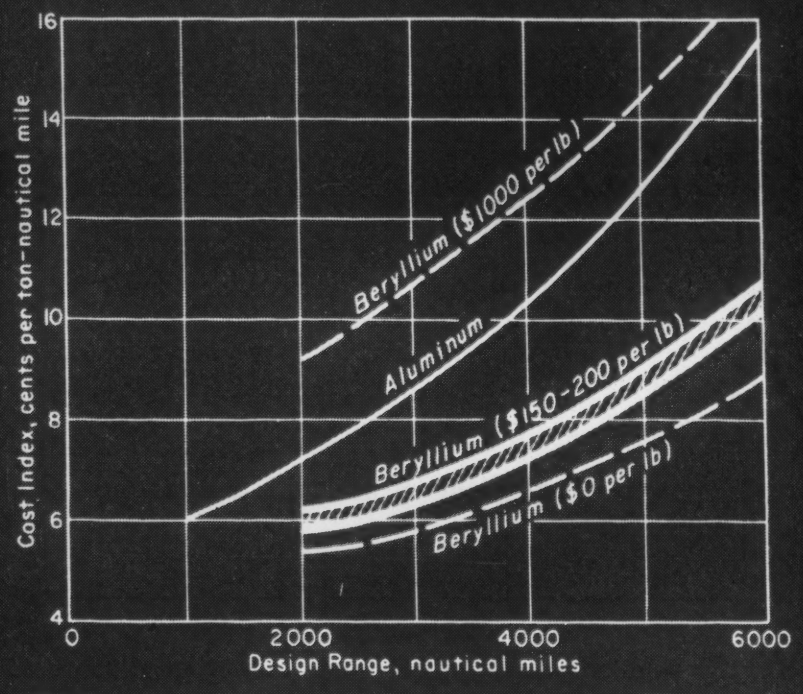


Fig 6 – *Cost index vs design range for beryllium and aluminum transports.*

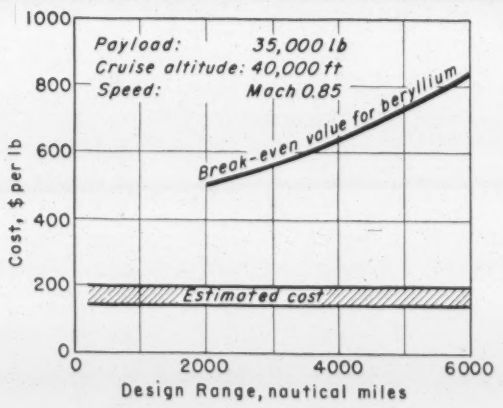


Fig 7—*Break-even cost of beryllium as a function of range.*

for elevated temperature tensile strength and modulus of elasticity are the highest values obtained for a specific grade rather than average figures.

Beryllium has the same density as magnesium — roughly two-thirds that of aluminum. Unlike magnesium, however, beryllium has a modulus of elasticity that is unusually high for a light metal—more than four times that of aluminum. This combination of light weight and high modulus gives beryllium a great advantage over other metals for structural use. However, the low ductility of the current product limits its value for structural purposes.

A structural evaluation

Using the best beryllium available today as a tentative example of future possibilities, this article compares beryllium with conventional structural metals. For this purpose, properties of beryllium, aluminum X7178-T6, stainless steel 17-7 PH and titanium 6Al-4V are given in Fig 1-4. The comparison distinguishes between structural elements designed for tensile loads and those designed for compressive buckling loads, and the comparison includes structures operating over a range of temperatures. It is assumed that beryllium is available in ductile form.

Tension elements — When tension criteria are used to design portions of an airplane structure, it is customary to compare weights of structures made of various materials by means of the ratio: density/tensile strength. The ratio for aluminum at 70 F is used as the basis for comparison. Fig 1 shows the relative weights of several materials at various temperatures. Beryllium tension structures appear lighter by a considerable margin. Comparison by this method omits consideration of fatigue and creep properties of the materials, but this method offers the best comparison possible with the information presently available. Few fatigue and creep data are available for beryllium.

Buckling elements — According

A transport airplane *of beryllium would weigh about half as much as one made of aluminum.*

PROPERTIES OF BERYLLIUM

PHYSICAL PROPERTIES	
Density, lb/cu in.	.066
Ther Cond, Btu/hr/sq ft/ft/°F	
70 F	87
1200 F	65
Coefficient of Expansion, per °F	
70 F	6.4×10^{-6}
1200 F	12.4×10^{-6}
Specific Heat, Btu/lb/°F	
70 F	0.46
1200 F	0.67
Modulus of Elasticity, psi	
70 F	44×10^{6}
600 F	43×10^{6}
1200 F	26×10^{6}
MECHANICAL PROPERTIES	
Tensile Strength, 1000 psi	
70 F	125
600 F	85
1200 F	31
Yield Strength (0.2% offset), 1000 psi	
70 F	95
600 F	65
1200 F	20
Elongation (hot pressed), %	
70 F	1-5
400 F	8-16
800 F	16-34
1200 F	10-14

Source: D. W. White and J. E. Burke, excepting elevated temperature strength and modulus values; these were the highest values obtained on extruded beryllium produced by Brush Beryllium Co. in 1955.

to Micks, the methods of optimum design provide the means for comparing materials used in thin-walled structures that are designed by buckling criteria. The sheet-stiffener panel is chosen as the basis of comparison since it behaves like other thin-walled structures loaded in compression, shear or bending.

Micks' procedure starts with the stress-strain curves of materials (Fig 2) and concludes with the equivalent allowable stress vs structural index curves shown in Fig 3. The equivalent allowable stress is usually defined as the buckling stress multiplied by the ratio: density of aluminum/density of material. The structural index is a design parameter relating the load that a structure must carry and the distance over which the load is transmitted. For panels, the index can be defined as the distributed load q (lb/in.) divided by the panel length L_o (in.).

The elastic lines are included in Fig 3 to indicate the importance of including the inelastic behavior of metals in a structural evaluation. For example, in Fig 1, based on elastic properties, magnesium appeared to be superior to aluminum. However, Fig 3 shows that this superiority is retained only up to an index of about 150 psi; beyond this point the inelastic behavior of magnesium causes it to be inferior to aluminum.

Curves of structural index vs allowable stress can be determined at different temperatures. To simplify the evaluation, an index of 300 psi (typical of a modern airplane) can be chosen as a particular example. Values of equivalent allowable stress at this structural index can then be used to calculate relative weights of panels of different materials at various temperatures. Fig 4 shows how the relative weights vary with temperature. Beryllium compression panels appear to weigh half as much as panels made of conventional materials at all temperatures.

Significance in aircraft

The proportion of an aircraft structure designed to resist buckling is usually greater than that designed to resist tension stresses. A recent estimate indicates that about two-thirds of the structural weight of a modern commercial transport is designed to resist buckling. The proportions of elements designed by tension and by buckling criteria are not too important when you are considering beryllium, since both types of beryllium structural elements weigh about 40% as much as aluminum members at room temperature.

However, the usual definition of an aircraft structure includes many items that may not be redesigned into another material such as beryllium. Although hypothetically beryllium could be substituted for other metals in about four-fifths of a modern transport structure, there still remains about one-fifth of the weight where beryllium could not be utilized. Using these ratios of 4/5 and 1/5, it can be concluded that a complete transport airplane structure of beryllium would

weigh about 0.52 as much as the aluminum structure. An accompanying example illustrates the effect of such weight reductions on the performance of an airplane.

Limitations of beryllium

There are a number of factors that prevent the use of beryllium in structural applications at present. These are brittleness, cost, availability and toxicity.

Brittleness—Brittleness is the major deterrent to the application of beryllium, and at present it is not clear whether the metal will ever qualify as an acceptable structural material for aircraft. None of the advantages of the metal can be utilized unless a solution of the brittleness problem is found.

Cost and availability — Beryllium powder costs about $100 per lb at present. Although improved methods of production will probably reduce costs in the future, economists estimate that cross-rolled sheet in significant quantities may still cost $100 per lb for years after continuous operations are started. Estimates of beryllium ore deposits indicate that sufficient quantities could be produced for limited use.

Toxicity — Beryllium is more toxic than lead on an equal weight basis. In the massive form, beryllium can be handled with the same precautions used for lead. However, beryllium and its compounds in finely divided form can cause acute lung irritations and various skin reactions.

Recognition of the health hazards of beryllium have led to the installation of suitable controls, and the metal is produced to a safety record comparable to that of a nonhazardous industry. However, protection from toxicity is estimated to add about $10 per lb to the cost of producing beryllium sheet and there may be an additional expenditure of $10 per lb for processing structural shapes into finished structures. At least part of this additional expense will result from the necessity of performing grinding and machining operations under ventilated enclosures.

Economics of a Hypothetical Airplane

To illustrate what a beryllium aircraft would be like, let us consider a turbojet-powered transport airplane capable of delivering a payload of 35,000 lb at a cruising speed of Mach 0.85. Such an airplane is similar in capability to some jet transports now being designed for commercial use. This example is hypothetical, however, since the airplane is assumed to be made of beryllium having the highest strength yet obtained in the laboratory, as well as elongation and other properties sufficient for structural use but not yet achieved.

The characteristics of the aluminum aircraft are based on the calculations of T. V. Jones, and the main features are:

Design payload	35,000 lb
Fuselage diameter	14.5 ft
Fuselage length	125 ft
Design cruising speed	Mach 0.85
Initial cruise altitude	40,000 ft
Wing sweepback angle	30 deg

Wing areas, gross take-off weights and other design parameters are varied to obtain different design ranges. The beryllium and aluminum aircraft are identical in powerplant, payload, speed, altitude and over-all dimensions; they differ only in range capability, fuel weight, structural design and material.

The structural weight of a beryllium transport is assumed to be 0.52 times the weight of an aluminum airplane. The structural weight reduction resulting from the theoretical beryllium design permits an increase in fuel weight equal to almost half the aluminum structural weight. This additional fuel extends the range of a beryllium transport beyond that of the aluminum transport of equal take-off weight, an effect shown in Fig 5, which was developed from procedures outlined by Jones.

A significant extension of range appears to result from using beryllium, but it is obtained only by using hypothetical material of high initial cost. The role of initial cost of the structural material can also be evaluated (by the methods of Jones) by comparing the operating cost indices of the two airplanes. The cost index is the cost of transporting a ton of payload over one nautical mile. It includes crew costs, fuel and oil costs, airframe plus powerplant depreciation, and maintenance expenditures. Cost indices for aluminum and beryllium transports are shown in Fig 6 using three hypothetical cost levels per installed pound of beryllium. The cost of $150-200 per lb is a rough estimate of the unit cost of a finished beryllium structure of the future, after intensive development.

Fig 6 shows that beryllium transports are more economical only if the installed unit cost of the structure falls below a certain level. The price level of beryllium airframes at which aluminum and beryllium transports are of equal capabilities and operating cost determines a break-even point (Fig 7). The break-even cost of beryllium is well above the estimated future cost of the material, and it increases with the range.

Acknowledgment

The author gratefully acknowledges the cooperation of W. R. Micks.

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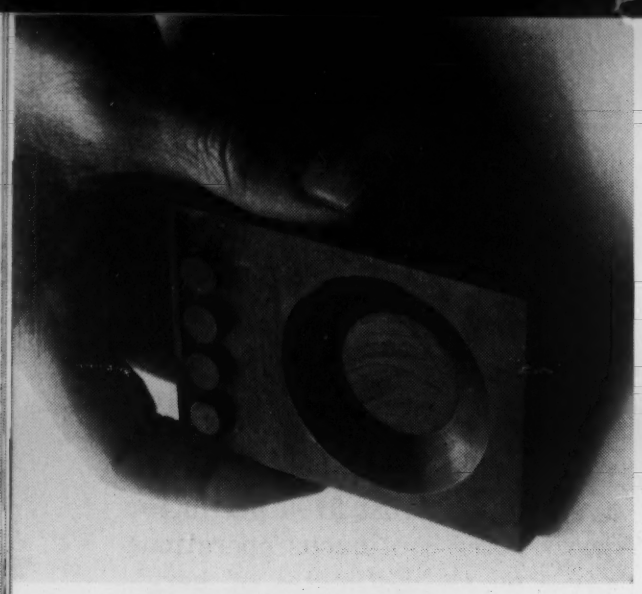

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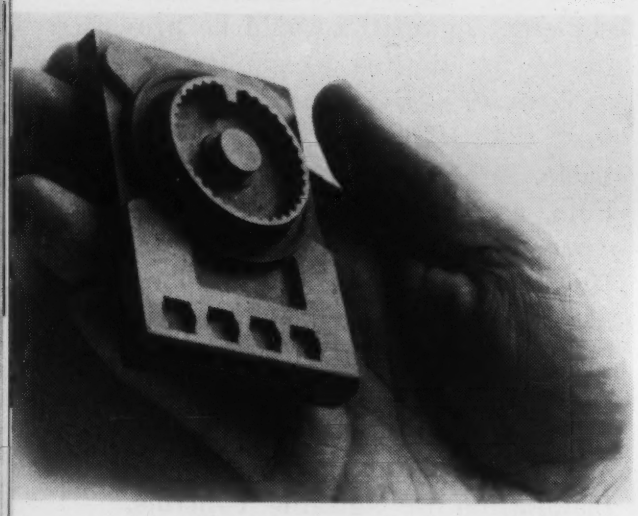
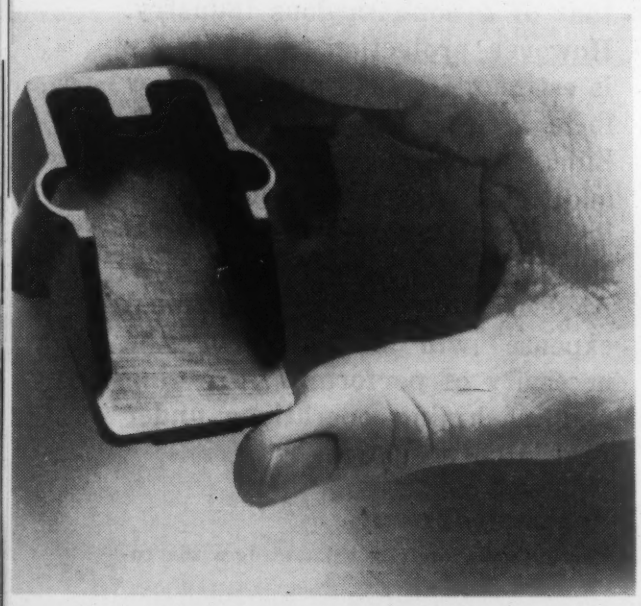
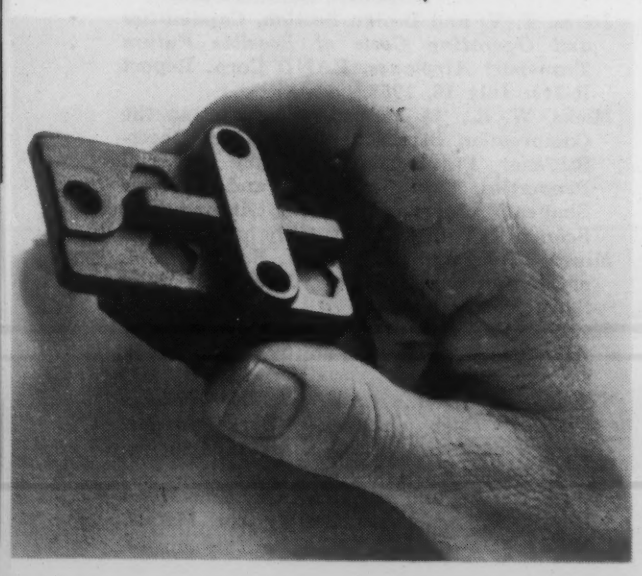




Thermostat cover ↕



Short-Run Plastics Parts...

They're pretty accurate, and the process is much cheaper than machining parts out of solid blocks.

by I. R. Axelrad, *Materials Engineering Dept. Westinghouse Electric Corp.*

■ This technique, similar to that used to make plaster novelty items, is suitable for models or prototypes and for production parts in quantities too small to warrant fabrication of compression or transfer molds. Use of flexible neoprene molds means that reentrant angles and other complex designs can be formed. Any casting resin that is compatible with neoprene can be used, though most of Westinghouse's work has been done with phenolics. The method can replace the current practice of machining parts from solid blocks of plastics, an expensive and time consuming method when more than three or four parts are needed.

How accurate?

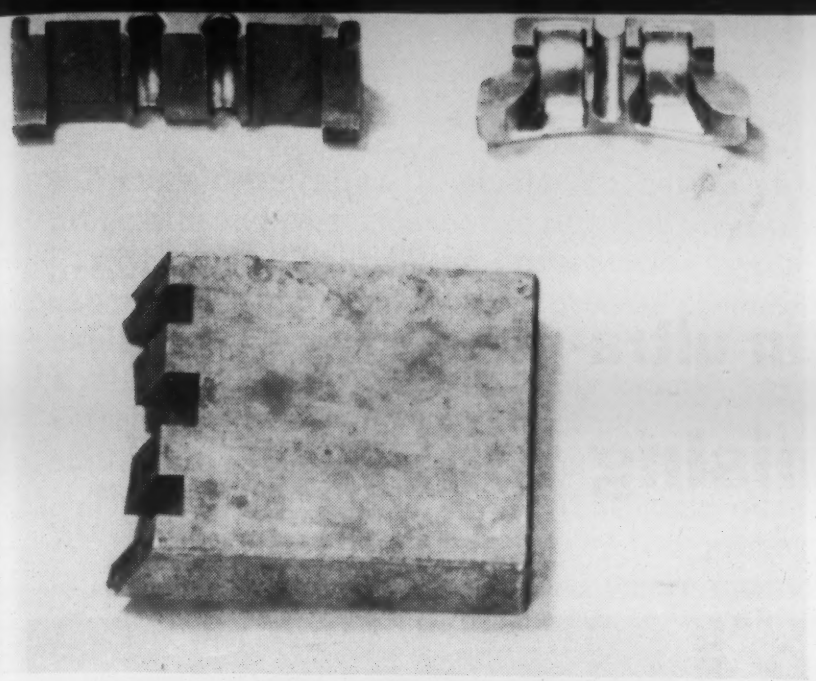
Although parts cast in rubber cannot be held to the tolerances possible with matched metal molds, a reasonable degree of accuracy is reproducible. For example, on cast phenolic parts, dimensions can be held to about ±0.004 in. per in. Typical accumulated tolerances on two parts produced by the method are ±0.012 in. on a 2.6 in. dimension; ±0.010 in. on a 2.685 in. dimension; and ±0.016 in. on a 2.603 in. dimension. The degree of accuracy obtainable on any part depends on the oversize allowance used in making the master pattern, the care with which the pattern is made, and the degree of accuracy attained in calculating amount of shrinkage during cure of the rubber mold and the cast resin.

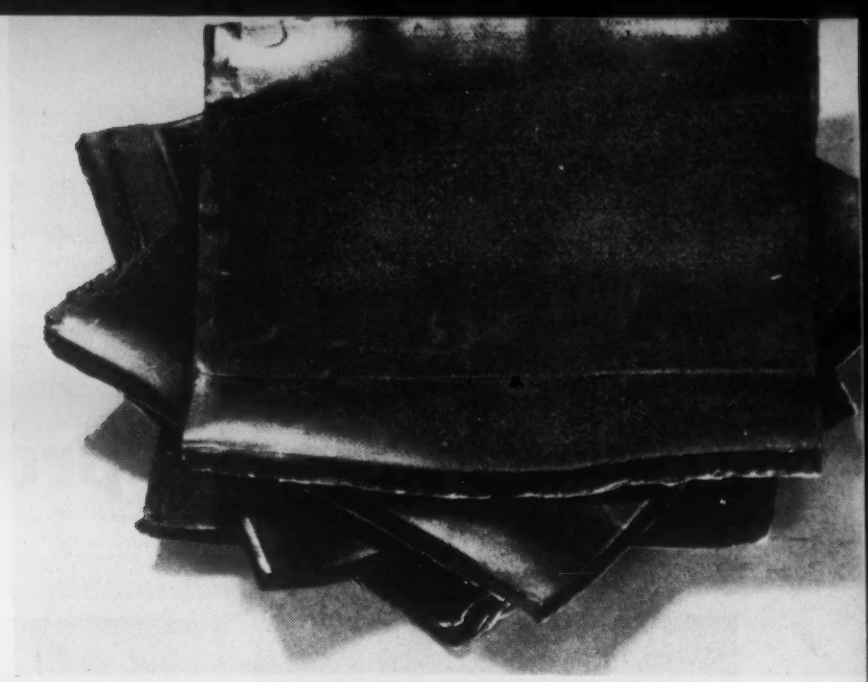
For maximum accuracy in both dimension and finish, steel master patterns should be used. Other materials, such as aluminum or a heat resistant plastic, can be used for simple patterns. Wood is unsatisfactory since it compresses during fabrication of the mold and accuracy is lost. Copper or brass is undesirable since the rubber tends to stick, producing a rough surface on the mold.

The master pattern must be made oversize to compensate for shrinkage of the rubber and the resin. The oversize factor is chosen empirically and varies depending on the size and shape of the cast part, the resin used, the particular neoprene used for the mold, the curing schedule of the mold and the curing schedule of the cast resin.

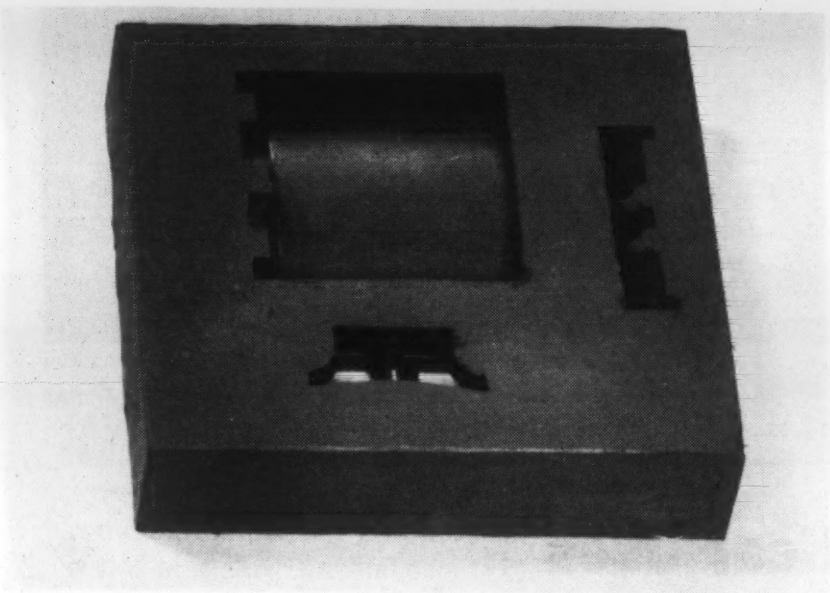
How it's done

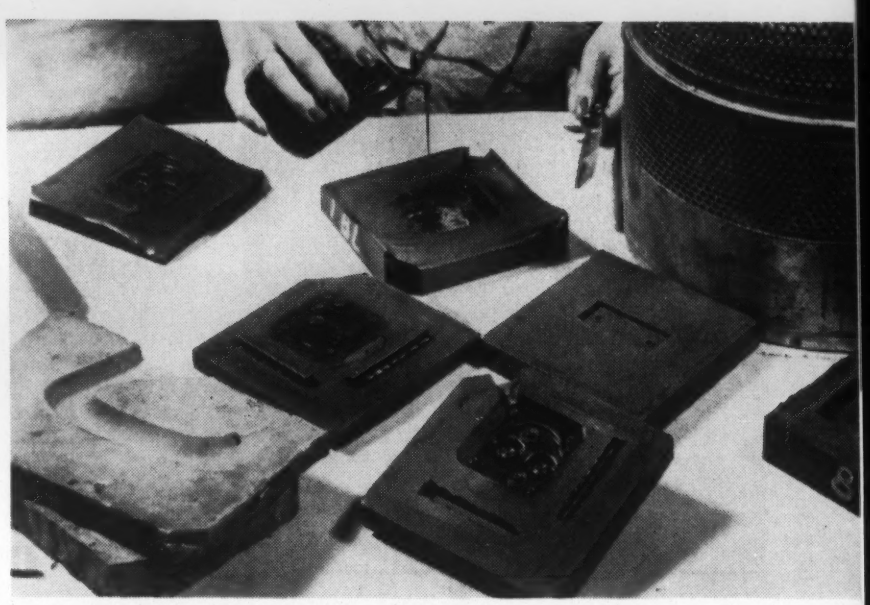
Making the mold—One- or two-piece molds can be made, depend-





Metal pattern is pressed into . . . neoprene sheets to form . . .





. . . finished mold. After cure . . . resin is poured to form part.

. . . cast in rubber molds

ing on the complexity of the part to be cast. One-piece molds are used for all parts having one flat side on which pressure can be exerted. They are formed by forcing the pattern into a stack of uncured neoprene sheets, cut to fit inside a pressing chamber. The pressing chamber is a shallow box with removable top and bottom plates machined to fit inside the box. The chamber containing the pattern and the neoprene sheets is placed in a press, heated to 300 F and pressed at 800-1500 psi for 20 min. After cooling, the cured neoprene mold is ready for use.

Two-piece molds, required for more complex parts, are formed in a similar manner. However, only about half the required sheets of uncured neoprene are placed in the pressing chamber. The pattern is centered on top of this stack, and the remaining sheets of rubber are placed over the pattern. Talc or starched cloth is used as a parting agent between the two mold halves. After pressing, gates for pouring the resin are cut in the neoprene.

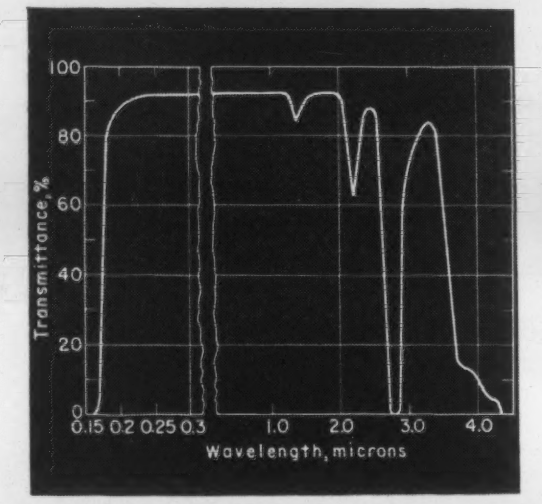
Pouring the resin — Phenolic casting resins are particularly well suited for forming by this method because they are solventless, have relatively low shrinkage, and can be cured rapidly at low temperatures. In filling the mold, part of the catalyzed resin is poured; then the mold is partially evacuated to remove trapped air. After the mold is filled it is again evacuated to ensure bubble-free castings.

Curing the casting—The parts are cured in the mold at about 170 F for 1 or 2 hr or until they are hard enough to maintain dimensional stability when they are stripped from the mold. Parts are then usually returned to the oven for a final cure for about 2 hr.

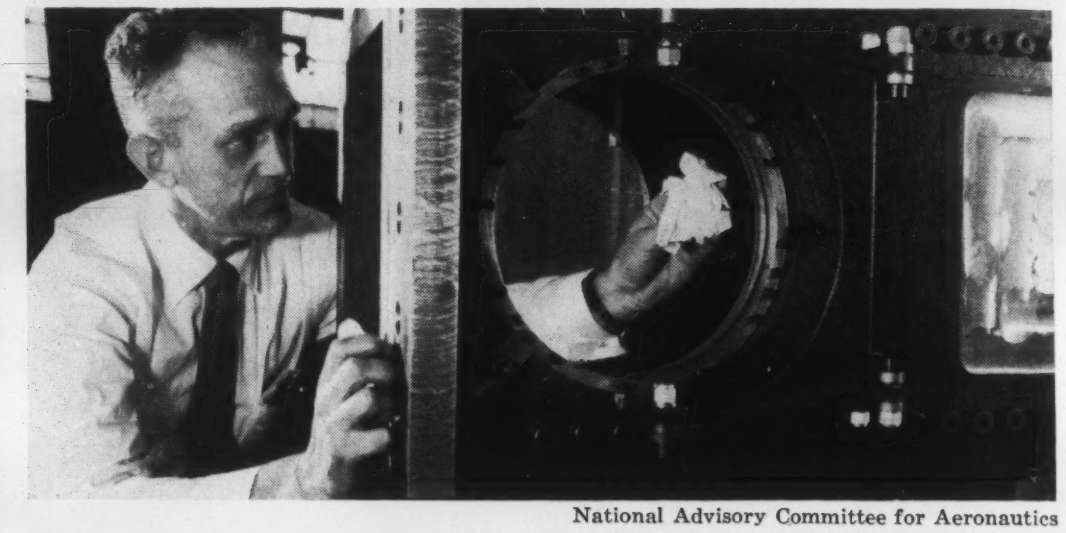
Finishing the part—Where the flat surface of a part cast in a one-piece mold is critical, it can be belt-ground using the mold as a holding fixture. After grinding, top surface radii can be restored by hand filing. Parts cast in two-piece molds generally require less finishing. The gate is cut or ground off and the gate area finished to match the surface of the rest of the part.

by **Charles H. Lucy,** *Corning Glass Works*

Fused Silica —an ultra-pure glass— looks promising for . . .



Transmittance *of fused silica 10 mm thick (including surface reflections).*



National Advisory Committee for Aeronautics

Window *for supersonic wind tunnel exploits combination of heat and thermal shock resistance and excellent optical qualities.*

OPTICAL PROPERTIES•

Rel Dispersion, "nu" value $\left(\frac{N_d-1}{N-N_e}\right)$	67.33
Birefringence Const, millimicrons/cm/kg/sq mm	340

•Source: Rodney, W. S., National Bureau of Standards.

EFFECT OF WAVELENGTH• ON REFRACTIVE INDEX

Wavelength, microns	Index of Refraction	
	Observed	Observed Minus Computed, x 10^5
0.34669	1.47752	−5
0.36117	1.47516	−6
0.365015	1.47456	−9
0.4046561	1.46965	−6
0.435835	1.46672	−5
0.546074	1.46010	−4
0.643847	1.45671	−5
1.01398	1.45024	−6
1.52952	1.44427	−7
1.97009	1.43853	−8
2.32542	1.43293	−10
3.2432	1.41321	−5
3.2666	1.41258	−5
3.3033	1.41163	−1
3.4188	1.40842	+3
3.5078	1.40570	−7

•Source: Rodney, W. S., National Bureau of Standards.

. . . optical uses

Due to its high structural purity, fused silica can be considered the most transparent glass made. Its light transmisson characteristics are particularly good in the far ultraviolet range (see graph). Transmissions of more than 90% through a 10 mm thickness at 1850 Ångstroms have been attained, though 80% is typical of standard stock. Among the applications that make use of these characteristics are optical systems for spectrophotometric and biochemical instruments requiring high ultraviolet transmission.

Variation of refractive index with wavelength in the visible range is shown in an accompanying table. Index gradient across a blank diameter can be held to less than 10^{-5} per in./in. on a selected basis.

Transmission in the infrared region for standard fused silica has a characteristic water absorption band at about 2.7 microns. Recent developments indicate that this band could be removed, at least for relatively thin sections.

Though the thermal behavior of fused silica is similar to that of natural fused quartz, the combination of this behavior with other exceptional properties lacking in quartz permits new high temperature optical applications. A typical example is the use of fused silica for Schlieren windows in high speed wind tunnels. The material meets the combined requirements of relatively good optical quality (index variation of less than 10^{-5} per in./in.) at high working temperatures (above 1650 F) over large diameters (18-20 in.).

In addition to these specialized optical fields, fused silica is an exceptionally good material for optical flats and mirrors due to low stress levels, uniform structure and low coefficient of expansion. Density and other mechanical properties are shown in the property table on the following page.

■ Though fused silica is similar in nature to fused quartz, its properties and performance are superior because of its high purity. Starting with liquid silicon tetrachloride, a complex purification, vaporization and condensation process produces solid silicon dioxide having impurity levels in some cases of less than one part in a million. This purity substantially reduces physical and chemical defects normally found in natural quartz and provides properties suitable for applications in several industrial fields.

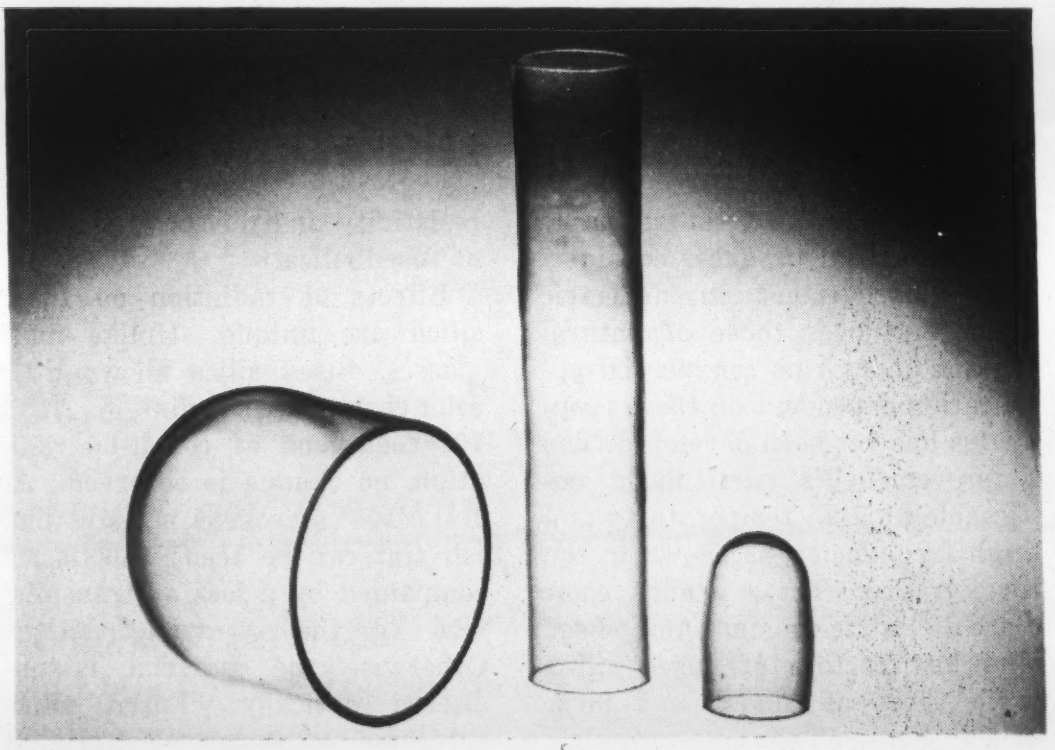
Though initially developed for acoustic ultrasonic delay lines, fused silica looks promising for optical prisms, for windows in wind tunnels, and for instruments where ultraviolet transmission is a critical requirement. Its combination of high purity and high temperature resistance makes fused silica also promising for applications such as crucibles and other process equipment handling molten semiconducting materials.

MECHANICAL AND THERMAL PROPERTIES

Density, gm/cu cm	2.2
Bulk Modulus, 10^6 psi	6.0
Rigidity Modulus, 10^6 psi	4.51
Young's Modulus, 10^6 psi	10
Poisson's Ratio	0.17
Strain Birefringence (max), psi	50
Softening Point (±18 F), F	1585
Annealing Point (±45 F), F	1075
Strain Point (±63 F), F	990
Coef of Ther Exp, per °F	3.1×10^{-7}
Ther Cond (r.t.), Btu/sq ft/hr/°F/in.	9.55
Specific Heat (r. t.)	0.17

. . . chemical uses

The high purity of fused silica combined with its high temperature stability promises important uses in the processing industries, particularly in those handling molten semiconductor elements. Fused silica is nominally pure silicon dioxide. Spectrographic analysis of standard ware shows traces of foreign material to the extent of less than one part per million. Where necessary, impurity levels can be reduced still further. This high purity level is most desirable in crucibles and tubing for the production of such materials as germanium. For this application boron impurity levels are critical. Mass spectrograph measurements have not detected any boron in fused silica, even at the level of one part in ten million.



Crucibles and piping *for processing semiconducting materials require high degree of purity.*

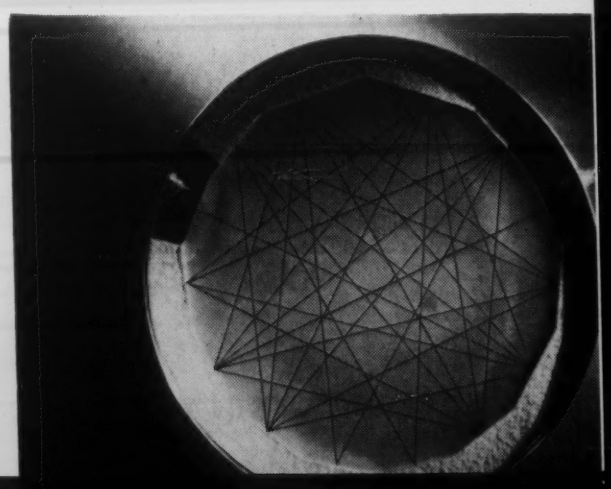
. . . ultrasonic uses

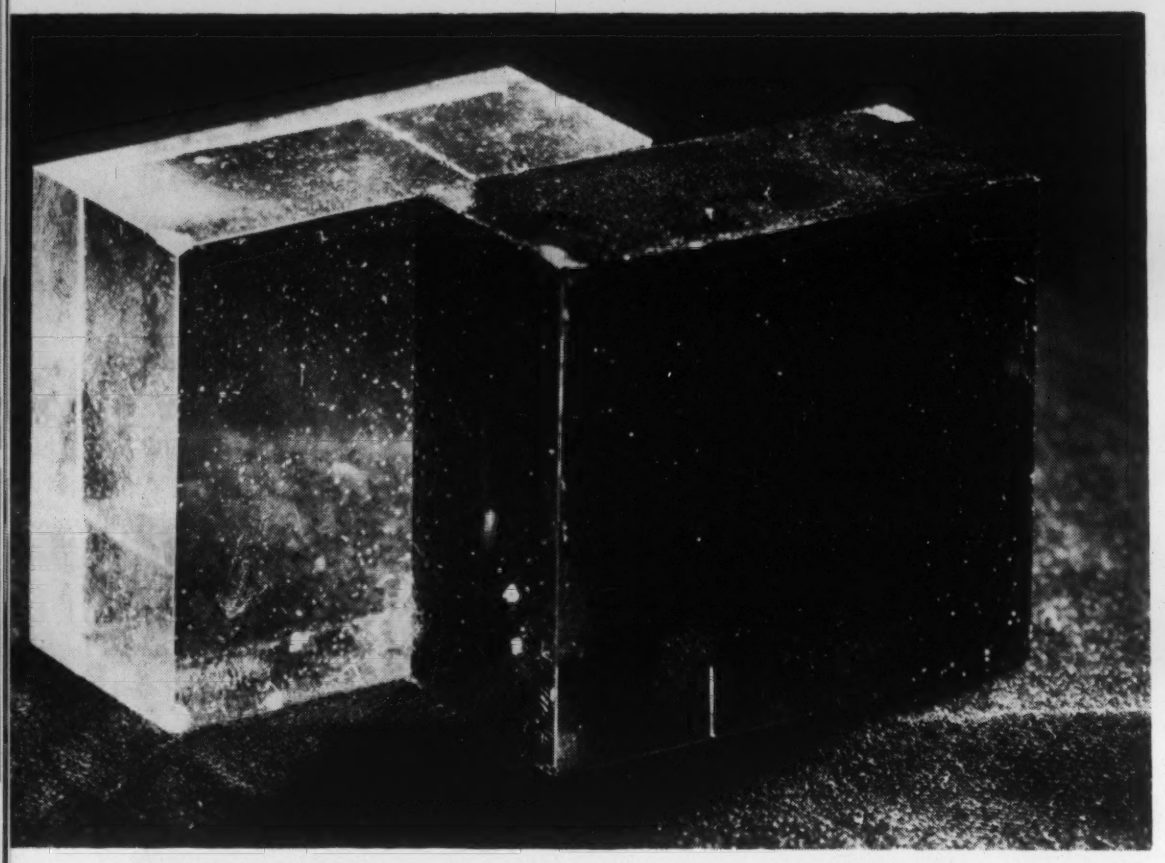
The combination of physical stability and low ultrasonic transmission losses makes fused silica an ideal propagation media in ultrasonic delay lines—the purpose for which the material was developed. Losses are approximately linear with frequencies up to the 30 or 40 mc region and are on the order of 0.02 decibels per ft-mc. Acoustic velocities and impedance are given in the accompanying table.

ULTRASONIC PROPERTIES

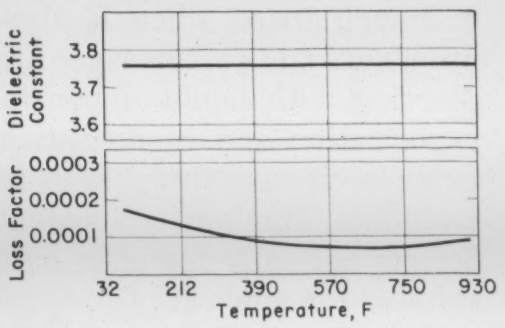
Shear Wave Velocity, 10^5 cm/sec	3.76
Shear Wave Impedance, 10^5 gm/sq cm/sec	8.27
Compress. Wave Velocity, 10^5 cm/sec	5.95
Compress. Wave Impedance, 10^5 gm/sq cm/sec	13.09

Delay line, *uncapped, shows fused silica embedded in unit. Drawn lines illustrate path of electrons.*

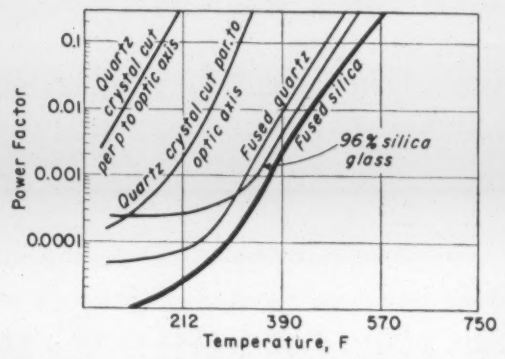




Common glasses *turn blue after relatively light irradiation dosages, whereas fused silica produces only a slight bluish tinge after extremely high dosages.*



Dielectric constant *and loss factor vs temperature for fused silica.*



Power factor vs temperature *(60 cps) for fused silica and other materials.*

. . . electrical and radiation uses

The low level of contaminants in fused silica produces considerable improvement in dielectric properties over those of natural quartz, though no commercial application dependent on these properties has yet been developed. The improvement is particularly noticeable at high temperatures and high frequencies, as shown in the two graphs. These graphs compare dielectric constant and power and loss factors of fused silica with those of quartz and 96% silica glass. The accompanying table shows the exceptionally high resistivity and dielectric strength of fused silica.

Effects of radiation on fused silica are unique. Unlike most glasses, fused silica shows little color change upon radiation. After 10^9 roentgens of cobalt-60 radiation, no change is observed. At 1.4×10^{10} roentgens a slight bluish tint can be seen; this is accompanied by a loss of transmission in the ultraviolet range. Otherwise the material is unaltered optically. Fused silica subjected to 2-mev electrons at the rate of 10^{-7} coulomb/sec/sq cm for 2½ hr (equivalent dose: 2×10^8 rep) shows no discoloration and no internal breakdown. As yet there are no commercial applications that depend primarily on the nuclear characteristics of the material.

ELECTRICAL PROPERTIES

Dielectric Constant (77 F, 1 mc)	3.8
Dielectric Loss Factor (1 mc)	
77 F	<0.0004
390 F	<0.0008
Power Factor (1 mc)	
377 F	<0.0001
90 F	<0.0002
Volume Resistivity, ohm-cm	10^{17}
Dielectric Strength, v/mil	500

Forms and Sizes Available

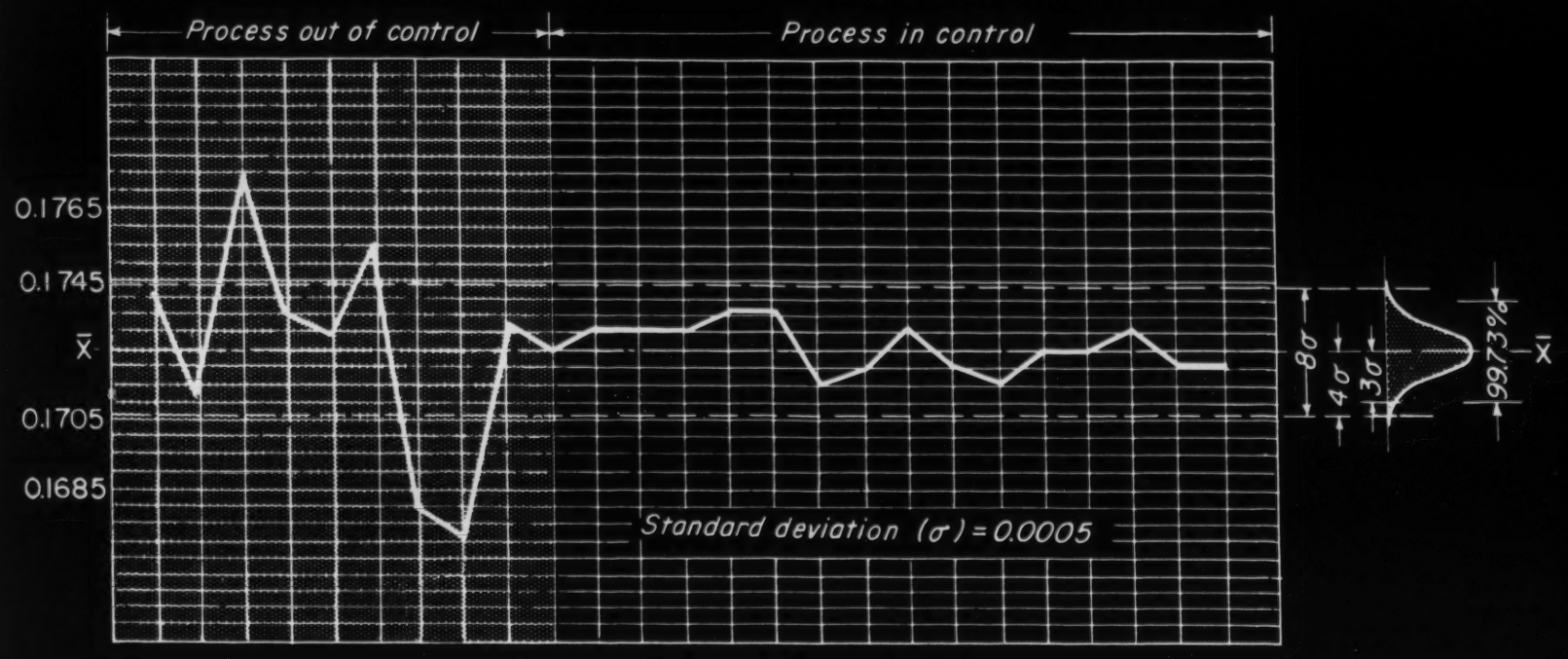
For ultrasonic and optical uses:

Dia. in.	Thickness (max), in.
17	½
15	1
14	2
18-20 (special order)	1-½

For ultraviolet uses:

Dia. in.	Thickness (max), in.
1½	5
3	3

Difficulty in forming is one of the major limitations of fused silica. Though from the chemical and physical standpoint it is the simplest glass made, its melting temperature is extremely high and well beyond the range of conventional furnaces. It can be cut, machined and ground like conventional glass, but its high melting point makes it difficult to mold or form, and no conventional technique has yet been found suitable. The material is currently available in circular sheets up to 2 in. thick, as can be seen in the accompanying box. Any odd shapes within the dimensional limits indicated, as well as rectangles, prisms and bars, can be cut from standard sheets.



Quality control chart *and the normal curve.*

Writing 'Specs'

Questions That Statistics Can Answer

The techniques of statistical quality control can give the engineer many facts that will help him write better materials specifications. Here is a brief discussion of some of the things that can be accomplished by the statistical approach.

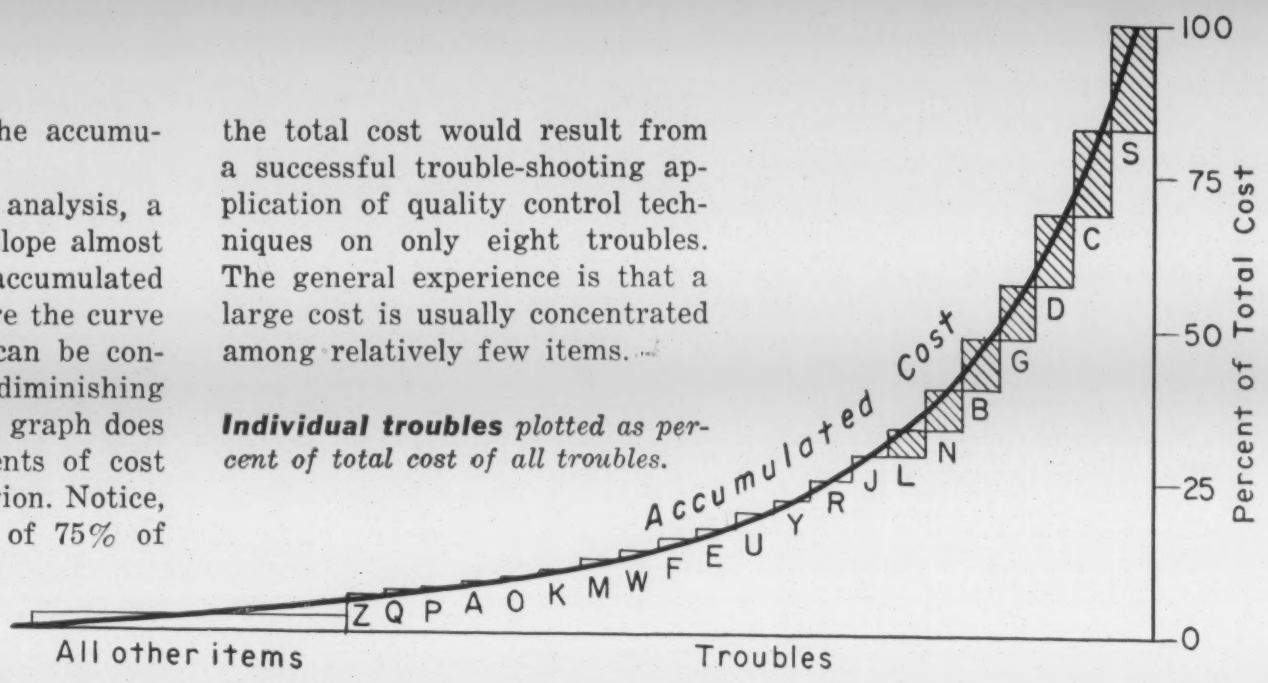
by Dorian Shainin, *Rath and Strong, Inc., Industrial Consultants*

1. Which variable must be controlled?

One way to determine which properties or requirements should be subjected to statistical analysis is to use the *relative cost evaluation method*. This approach is illustrated by the chart at top of the next page. The chart represents an orderly plotting of troubles against percent of total cost of all troubles. Trouble S was the most costly for the period being studied. Its percentage of the total cost is shown by the cross-hatched bar (about 18%). Trouble C was the next most costly (about 10%), and so forth, as we move to the left. The curve connecting the tops of

the bars represents the accumulated cost.

In this sort of an analysis, a noticeable change of slope almost always occurs in the accumulated curve. The place where the curve starts to flatten out can be considered a point of diminishing returns. Note that the graph does not show the increments of cost per trouble in this region. Notice, too, that a reduction of 75% of the total cost would result from a successful trouble-shooting application of quality control techniques on only eight troubles. The general experience is that a large cost is usually concentrated among relatively few items.



***Individual troubles** plotted as percent of total cost of all troubles.*

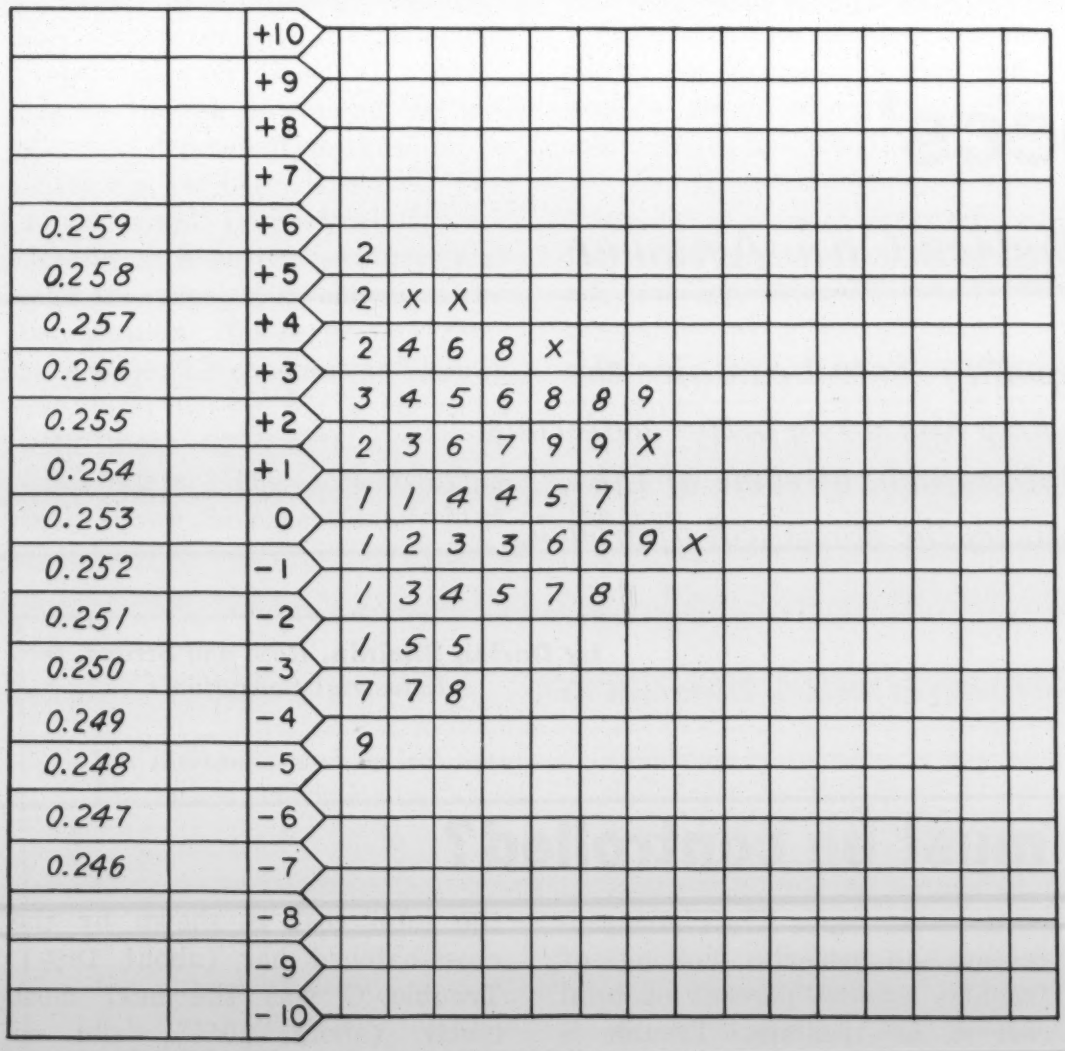
2. How closely can it be controlled?

To establish realistic limits for properties of a material or form, it is important to know the capabilities or inherent variations of the manufacturing process. One way of revealing process capability is to chart variations in the process or product as shown in Fig 2. Such charts, called histograms, show the range of results and the frequency with which the various results occur. In addition, quality control engineers also test successive ranges of smaller groups of results to confirm that the process is truly operating in statistical control.

Technically, the inherent capability of a process or method is termed the *natural tolerance* and is defined as the numerical width of the band of the expected variation of individual results when the process is operating in statistical control (see accompanying box). Quality control men often refer to the natural tolerance as the 6σ (six standard deviations) width. Experience has shown that a good rule of thumb is to set the limits for a process no closer than 8σ apart. Thus, ample recognition is given to the economical necessity of living with variations having certain assignable causes. A minimum "operating range" of 133% makes a product or process practical. If the tolerance is one-sided, having only a maximum or only a minimum limit, this point of view calls for at least 4σ between the limit and the desirable or expected average value.

Clearly valuable for specification purposes, then, is a list of the process capabilities in a plant. When the functional requirements of the product seem not to permit 8σ for the tolerance of a characteristic on one component of an assembly, it is sometimes possible to change the tolerance on a mating component to allow the greater tolerance for the part in question.

By using this natural tolerance concept, a proposed change in specification limits can be readily evaluated. Consider two cases where a 50% increase in specification tolerance is planned. In one case, say, the process capabil-



***Inherent variation** in a process is revealed by this histogram. First five results are marked with a 1, the second five with a 2, etc.*

ity is found to be equal to the existing tolerance; the proposed change will give an "operating range" of 150%. In the other case the process capability is found to be one-half the tolerance; the same 50% increase in tolerance will result in an operating range of 300%.

3. How much does it actually affect the end product?

In developing specifications it is often important to know how much of the total variability of a process or a product comes from the variability of one or more specific factors and how much comes from the remaining non-analyzed factors. A statistical approach called *analysis of variance* can often provide this information. The following brief descriptions of two techniques used in analysis of variance show the general nature of the approach.

Balancing—This technique can be used to show how different values of the variable factors will affect the results. By systematic design of experiments, various combinations of the variable factors can be tested to furnish the desired information. For example, the combinations can be so chosen that when the results common to one value of a factor are compared with the results common to another value of the same factor, the values of all other factors will have contributed equally to each of these two sets of results. Thus, the effects of the other factors will have been balanced out, and the difference in results can be attributed to the change in value of the one factor alone.

Randomizing — This technique is used to prevent any one or more of the remaining, and non-analyzed factors from having anything but a random effect upon the results. Random effects, of course, can be handled statistically. In randomizing, it is usually the selection of test material and the order of the test run that is made to follow the random pattern.

Another question that can be answered by analysis of variance is how likely is it that two or more factors will have certain specified values, simultaneously. Here we are implying that a particular combination of levels of different factors can sometimes give a result all out of proportion to what the experiment shows can be expected as each factor might be taken to a different level. Such an unusual result is called an *interaction* effect. How often such critical combinations might actually exist can be determined by probability calculations based on the observed distribution of factors in the field.

This article is based on a chapter in the book, "Quality Control for Plastics Engineers" prepared by the Quality Control Committee of the Society of Plastics Engineers, Inc. The book is published by Reinhold Publishing Corp.

What is a Good and Workable Spec?

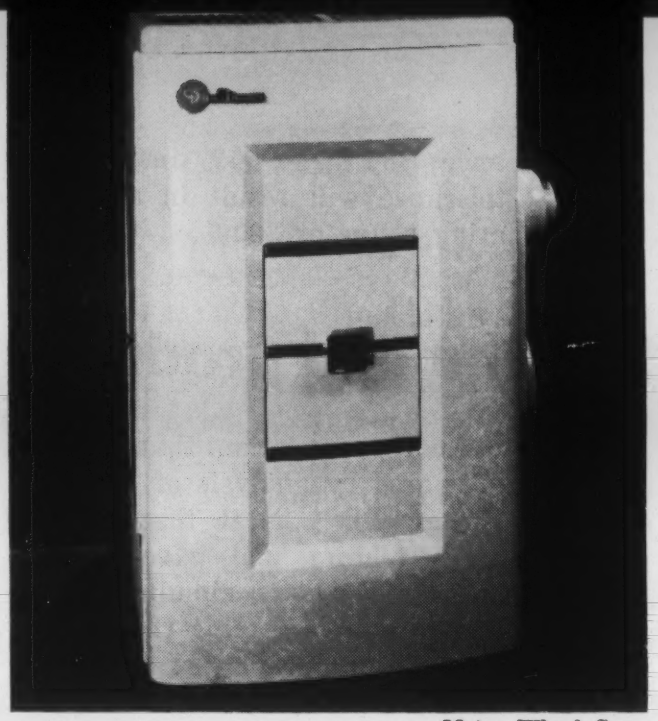
The value of a specification is closely related to the nature and accuracy of the limits it establishes for various properties or requirements. Properties or requirements for which limits can be set on a plastics molding, for example, include dimensional fits and clearances, minimum tensile and impact strength, weight loss resistance to solvents, water absorption and electrical properties. In a good specification, the limits are such that if the product meets them, the product will also successfully meet the real use requirements. In addition, the established limits must be such as to permit the product to be readily made using present practical fabrication technology.

To transform a good specification into a workable one, you need standards against which the limits can be judged as well as rules for inspection. A specification that does all this represents a successful balance between the viewpoints of the producer and the consumer.

Some Common Results of Statistical Analysis

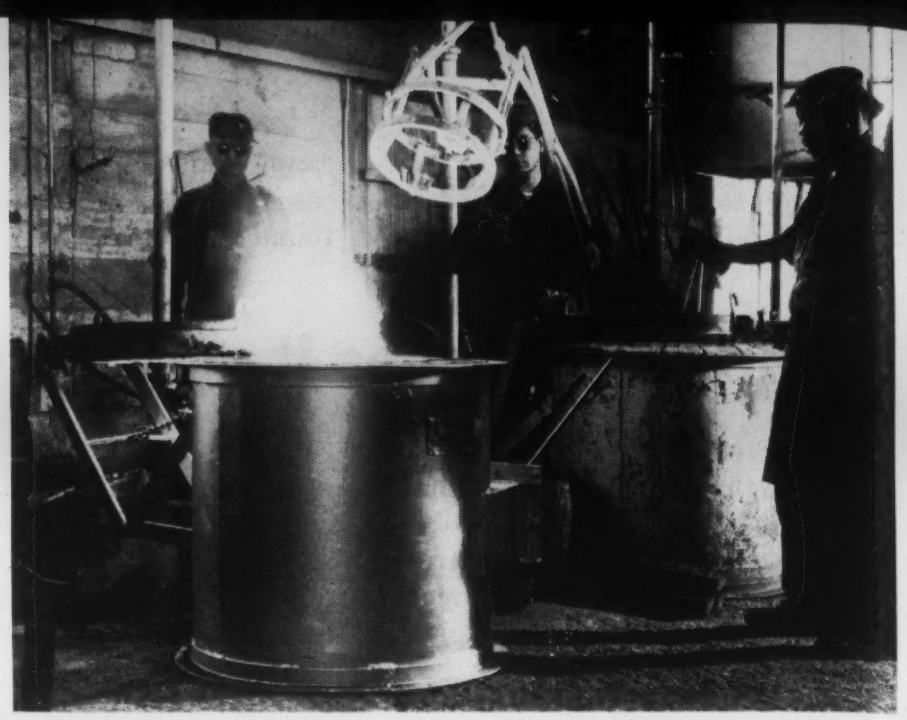
Generally, it has been found that although most tolerances are unnecessarily close ("tight" or "conservative") from a functional standpoint, still there have been very few that could not be met economically with the aid of quality control techniques of the appropriate type. Statistical analysis often results in one or more of the following conclusions:

1. That, contrary to general belief, a troublesome process could easily be made to meet the specification requirements. In some cases the operator was making unnecessary adjustments which were shifting an otherwise stable distribution of results. In other cases the automatic control mechanism was increasing the total variability by introducing this type of adjustment hunting. In these cases the specification was realistic, but the process was being operated in such a way that its inherent capability was being unnecessarily exceeded.
2. That the specification had set up controls for some factors that analysis of variance showed had little effect, yet disregarded some *one* factor that had a major effect on the results.
3. That a pertinent factor was being controlled, but at the wrong level for the desired results.
4. That two factors, when simultaneously at a particular pair of levels, gave a result significantly different from that which would be expected from plotting the change in results due to changes in each factor alone. This interaction effect can only be evaluated numerically (and often can only be discovered) by the use of certain experimental designs which are part of analysis of variance.



Motor Wheel Corp.

Space heater grill *uses platinum-modified silicone coating to withstand long service at temperatures as high as 450 F.*



Floor furnace *in foreground uses silicone-aluminum paint to withstand constant temperature fluctuations from room temperature to 500 F.*

These are some current uses of . . .

Silicone Coatings

These coatings have excellent resistance to heat, moisture, salt spray, acids and alkalies. Suitably modified, they also provide hardness, flexibility and abrasion resistance.

by L. F. Stebleton, *Dow Corning Corp.*

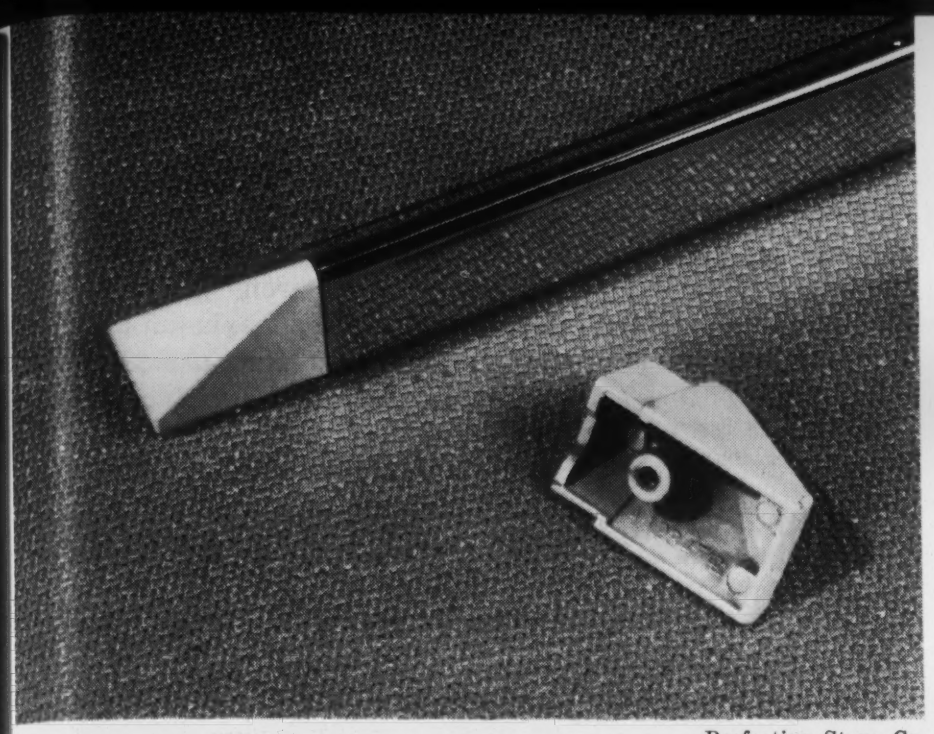
■ It is often difficult to determine just what constitutes a silicone coating. Descriptions such as "silicone-based," "modified silicone," "silicone-containing," and even "straight silicone" all tend to overlap in referring to formulations whose actual silicone content may range from 100% to as little as 5%. Coatings with a high silicone content possess high resistance to heat and moisture. High silicone content, however, does not necessarily indicate that a coating will provide the best all-around performance in any given application. In many cases some of the low silicone coatings that are deficient in heat and corrosion resistance possess other properties that are superior to those of high silicone coatings.

Types—In general, silicone coatings may be divided roughly into three types: glossy baking enamels, metallic pigmented coatings and specialty coatings. The amount of silicone resin in any commercial finish is usually indicated by two factors: the cost of the finish and the curing time required. Since the cost of silicone resins is relatively high ($3.00 per lb for 100% solids, compared to $0.50 for alkyds), the higher the cost of a silicone finish, the higher is likely to be the silicone resin content. Similarly, the higher the baking temperature required (up to 30 min at 600 F), the higher is likely to be the silicone content. Excepted from this rule are certain new specialty finishes which contain drying oils to accelerate air drying but which retain fairly good high temperature properties.

The chief advantage of silicone coatings is their heat resistance. Commercial white enamels retain their film integrity at temperatures as high as 750 F—almost midway in the range between conventional paints and inorganic coatings like porcelain. For the most part, materials and application costs and physical properties are in this same midway range.

Most silicone paints are designed for service at temperatures just beyond the limits of conventional coatings. They provide excellent resistance to oxidation and weathering and possess good color and gloss retention. The coatings also have a remarkably high order of water repellency and moisture resistance, and are excellent electrical insulators. Fully cured coatings possess excellent resistance to salt spray, acids and alkalies. Their resistance to these media below 350 F, however, is not as good as that of the vinyls or epoxies.

Painted surfaces are quite easy to keep clean because of their high resistance to dirt adhesion. Since they are inert, silicones do not promote the growth of bacteria. Their primary advantage



Perfection Stove Co.

End brackets *of hot air deflector use modified silicone coating.*

Grieve Hendy, Inc.

Electric oven drawers *use silicone-aluminum paint on interiors to withstand temperatures up to 1000 F.*

for Metal Products

in combating such growths, however, is their innate water repellency and moisture resistance.

This same relative inertness results in limited adhesion. Silicone coatings also tend to be soft, despite any increases in baking times. These factors, coupled with high cost, have stimulated manufacturers to develop a number of coatings intended to provide the best possible performance at the lowest possible price. As a result, thousands of special formulations are available, each of which is designed for a specific end use.

Uses—In general, the greatest potential of silicone coatings lies in their use as: 1) heat resistant coatings for stoves and space heaters, 2) specialty finishes for automobiles, 3) dielectric coatings for electrical and electronic equipment, and 4) skin coatings for highspeed aircraft. To date, the high temperature properties of silicone coatings have been emphasized. However, with the increased development of special additive formulations, the greatest potential advantage of silicone finishes may lie in their superior resistance to weathering. One test report cites a white enamel that has withstood two years of exposure in southern Florida with no yellowing, chalking, crazing, dirt collection or mildew growth. Under these conditions even the best alkyds show chalking within six to ten months.

Baking enamels

Baking enamels are generally broken down by their silicone content—high, medium or low. The approximate cost and various properties of these coatings in relation to their silicone content are listed in the accompanying table.

Color—Color is an important factor in establishing cost of the coatings. A high temperature white coating, for example, is expensive because a 100% silicone vehicle must be used. The presence of just a trace of modifying resin causes prompt discoloration. However, if surface temperatures can be held down to 450 or 500 F, or if a darker or "off-white" color can be tolerated, then it is possible to use a less expensive coating with a lower silicone content.

Another variable factor is the relative importance of gloss and color retention. At high temperatures, a dark original color does not appear to lose its gloss and luster and become dull. In contrast, a light color does darken, but appears to retain its gloss. These changes seem to accelerate with high temperatures and where coatings have extreme colors and a low silicone content. Several manufacturers of space heaters have found low-silicone coatings satisfactory even in light colors. They reason that fading of the original color occurs so gradually that it is hardly noticeable to the user. Other manufacturers utilize medium-silicone coatings, but design their heaters

Third in a Series

This is the third in a series of articles on synthetic resin-base coatings for metal products. Previous articles were on acrylic (Dec '56) and phenolic (Jan '57) coatings. Future articles will cover epoxies and vinyls.

TYPICAL PROPERTIES OF SILICONE BAKING ENAMELS

Silicone Content of Vehicle, %	Color	Cure	Gloss and Color Retention	Max Operating Temp F	Cost, ¢/sq ft/mil dry	Applications
100	White	30 min at 450 F	Excellent	500	Up to 7	Porcelain touch-up, incinerators
65–85	Light colors	15–30 min at 400–425 F	Good to excellent	450–500	3–5	Space heater casings, furnace exteriors, etc.
10–70	Dark colors	Air dry or 5 min at 350–400 F	Fair to good satin finishes	Up to 450	2–4	Exhaust manifolds, space heater combustion chambers, trim and nameplates

so that only certain sections are subjected to high temperatures. Thus, the remaining sections can be coated with lower cost matching or contrasting organic finishes.

Inorganic coloring pigments must be specified when high temperatures are encountered. Some of the pigments commonly used, besides titanium dioxide, include: zinc oxide white (lead-free); cadmium sulfide and selinide yellows, oranges, reds and maroons; chromic oxide green; red iron oxide; cobalt blue; and graphite, mica and ceramic blacks. A number of inert extenders are also available where gloss is not required.

Silicones help to provide brighter tints and shades because they are almost colorless and require little or no vehicle covering themselves. However, the cost per equivalent hiding power of some of the pigmented silicone enamels is high. The pigment in a red, high temperature enamel, for example, may cost three to five times as much as that in a conventional enamel.

Modified baking enamels—The end use of a silicone coating determines the amount and kind of organic or modifying portion of vehicle required. Modified silicone paints were developed primarily for better physical properties and lower cost, but at the expense of some loss in heat and corrosion resistance. The number of possible variations runs into the thousands.

Silicone manufacturers themselves offer several basic 100% silicone resins, each of which have slightly different properties, and all of which can be mixed with each other to produce variations of these properties. Many intermediate silicone resins are also available. These materials can be modified with various proportions of organic resins including alkyds, phenolics, coumarones, ester gums, epoxies, acrylics and cellulose derivatives. Almost all of these formulations are designed for a specific, individual end use. Thus, it is evident that the designer must work closely with the formulator to obtain the optimum finish for his particular product.

Application and curing—Silicone baking enamels may be applied by any of the conventional methods. Most enamels are designed for spraying, but formulations can be adjusted for dipping, silk screening, roller coating and brushing.

A good degreasing is all that mild steel requires prior to silicone enameling. Sandblasting may be required for maintenance work to remove rust and old paint. Sandblasting frequently leaves sharp peaks and valleys which can be covered only with comparatively thick, heavy coatings. However, the process does improve adhesion. Tests indicate that maximum adhesion is obtained on sandblasted steel, aluminum, magnesium and tin plate. Fair adhesion is obtained on smooth steel. Adhesion is relatively poor on copper, zinc plate or galvanized surfaces.

There is some difference of opinion on the value of phosphate treatments. Some formulators recommend them for all of their silicone finishes, whereas others recommend an iron phosphate treatment only for maximum heat resistance and a zinc phosphate treatment only for added corrosion resistance.

Most silicone enamels cover about 500 sq ft per gal per mil dry. A single coat is usually sufficient, but two coats or a primer and a topcoat may be required for special applications. Silicone primers are rarely used on original equipment. They are used, however, as adhesion-promoting undercoats on oil refinery furnaces, towers and stacks operating from 500 to 1000 F.

The curing temperature of silicone enamels ranges from room temperature (air dry) up to 600 F. In many applications, formulations can be selected so that the coating is partially stabilized by air drying, the rest of the cure being accomplished at the operating temperature of the metal surface when the unit goes into service. This method is understandably popular in the maintenance of stacks, boilers and furnaces which cannot be baked. Success of this method of application requires that there be:

1. No abrasion until the coating is fully cured.

2. No prolonged delay or exposure to wet weather before curing is complete. Delay allows pigment to settle, turning aluminum, for instance, a plain gray. Rain streaks the surface and promotes rusting.

3. A graduated rise to maximum temperature, preferably over several hours or even days. A sudden rise to top temperature cures the bottom of the coating before the top, causing cracking and blistering.

In some applications silicone coatings have cured faster than previously used organic coatings. The coatings are difficult to overcure and have withstood oven baking for several hours at 450 F without any traces of failure. However, there is some danger of under-baking silicone enamels.

This danger increases in rough proportion to the silicone content. Under-baked films are relatively soft, adhere poorly, and tend to craze when handled or shipped in cold weather.

Uses—Applications of silicone enamels are increasing steadily. Originally used on space heaters, they are now applied to such things as transformers, motors, sun lamps, x-ray equipment, biological sterilizers, projector lamps and radio tubes.

Metallic-pigmented coatings

Silicone coatings received their first real impetus as aluminum-pigmented, 100% silicone resin coatings for maintenance work. When formulators developed modified coatings with greater adhesion and lower cost (at some expense to heat and corrosion resistance) the coatings became widely used for original equipment applications where protection was more important than appearance.

Several metallic-pigmented coatings have been developed to serve as high as 1200 and even 1500 F. These coatings are not enamels but are heavily loaded with metallic pigments such as powdered aluminum or zinc dust. The primary advantage of the silicone vehicle is that it provides corrosion protection to much higher temperatures than any organic resin can withstand. Upon prolonged heating from 700 to 1000 F the silicone gradually volatilizes, but its matrix still holds the metal pigment firmly in place.

The decorative appeal of silicone-aluminum formulations can be increased when they are combined with certain colored pigments to produce ranges of "satin" or "metalescent" shades. These special blends are usually diluted with xylene or toluene and used on trim and nameplates. They are generally cured by air drying 30 min to 1 hr to evolve the solvent, followed by oven baking from 3 hr at 350 F to 30 min at 600 F, depending on the silicone content.

Silicone-aluminum coatings must often meet military specifications for fuel and oil resistance. These specifications frequently call for coatings that can withstand such tests as SAE No. 30 oil at 150 F for 2 hr, ASTM Reference Fuel A at 80 F for 24 hr, and ASTM oil No. 3 at 300 F for 24 hr. Tests for resistance to salt spray and plain boiling water are also frequently specified.

Metallic-pigmented coatings have many applications in space heater combustion chambers, incinerator interiors, mufflers and exhaust systems, electrical equipment, heat echangers, high pressure steam lines, furnace casings, arc light reflectors and gas range shields.

Specialty coatings

A number of formulators have taken advantage of the prestige value of silicones by publicizing and advertising "siliconized" finishes. These formulations usually contain less than 1% silicone fluid. This fluid is no more than an additive but it does have an effect on the finish in the form of improved flow-out, better wetting of silicone-polished surfaces, improved pigment wetting in flat finishes, and less tendency to bubble in varnishes.

More important from the user's standpoint is the use of the silicone resins themselves as additives. These resins are specially developed for compatibility when cold-blended with conventional organic formulations. Since the proportion of additive can reach as high as 35% or more, there is some question as to just what is a silicone coating.

The difference seems to be one of intent. Whereas practically all of the earlier silicone coatings were formulated mainly for heat resistance and secondarily for mechanical properties, the newer silicone additive coatings are *primarily* strong mechanical coatings with *improved* heat stability and moisture and oxidation resistance.

Though billed as silicone finishes, some of these special formulations might better be described as very superior alkyd-amines. Their primary advantages, none of which are usually associated with silicones, are superior hardness, flexibility and resistance to abrasion, chipping and staining. None of the whites in this group are recommended for service at temperatures much over 250 F. Darker colors can be used up to 500 F without apparent discoloration. These coatings are principally recommended for consumer products such as refrigerators, ranges and washers. When used in industrial applications, however, they are claimed to provide protection equal to galvanizing at less cost and with better appearance.

The wide range of applications for specialty coatings is indicated by the following examples of current formulations:

1. A combination of silicone resin, ceramic frit and pigment that exhibits excellent color retention and resistance to salt spray at temperatures up to 1000 F. Applications in jet aircraft and guided missiles are foreseen.

2. An aerodynamic smoothing compound that is midway between a coating and a caulking. When applied to the exterior seams and joints of highspeed aircraft, it provides a smooth surface and reduces skin turbulence.

3. Coatings specifically developed for electronic components. Coated resistors, for example, cost less than the ceramic type and possess excellent dielectric strength and moisture resistance up to 550 F. Some ceramic resistors utilize a silicone enamel topcoat for improved resistance to humidity and salt spray.

4. A stop-off coating for surfaces to be galvanized. The silicone resists the chemicals and heat encountered and prevents the molten zinc from adhering to the base metal.

5. Transparent silicone-based gold lacquers for nameplates and trim. Work is also being done on the use of heat stable dyes as pigments for transparent and translucent coatings for window lighting lamps, traffic light lenses and similar applications.

Cold drawing *produces tubing having closer tolerances than hot rolled pipe. Drawing is followed by* . . . . . .

Close Tolerance Wrought Iron Tubing

Recent availability of cold drawn tubing means the good corrosion resistance of wrought iron can now be used in applications that previously were not feasible.

by H. K. Siefers, Jr., *A. M. Byers Co.*

■ The introduction of cold drawn wrought iron tubing permits the use of this well known material in applications where hot rolled tubular products were unsuitable because of design limitations. The principal advantages of cold drawing are the closer tolerances obtained.

Tolerances for cold drawn wrought iron tubes are compared with those for hot rolled pipe in table (p 117). The allowable variations in wall thickness for cold drawn tubing are 0% undersize, 22% oversize. These compare with 12½% undersize and unlimited oversize for hot rolled material. The outside diameter tolerances for cold drawn tubing are also much closer than those governing hot rolled material. These close tolerances are required for certain tubular product applications.

For example, in installing tubing in the crown sheets of heat exchangers by rolling-in or tube expansion methods, it is desirable to expand the end of the tube as little as possible in order to obtain a tight fit between tube ends and crown sheet. During installation, practically the entire tube must be passed through the hole in the crown sheet and satisfactory results are obtained only if close tolerances are maintained on both sheet and tube. Tolerances on hot rolled wrought iron tubes are not close enough to permit tube installations in most heat exchangers by the usual tube expansion methods.

Properties of wrought iron

Typical properties of wrought iron are given on the next page. Since cold drawing is followed by annealing, the mechanical properties of cold drawn material are similar to those of hot rolled wrought iron. As a result of the iron silicate inclusions in wrought iron, its longitudinal ductility is greater than its transverse ductility. However, its transverse ductility permits a tube expansion of 2 to 2½% of its diameter, an amount sufficient to obtain tight and secure joints.

The fine dispersion of thin silicate inclusions that is characteristic of wrought iron makes it unique among the ferrous metals. The threads of silicate interrupt the granular pattern of the base metal and give it a fibrous pattern. Refining, rolling and cold drawing assure a complete and uniform distribution of silicate throughout. This distribution is important because the silicate im-

. . . **annealing** *to restore the ductility characteristic of wrought iron.*

parts its corrosion resisting properties to the iron by acting as a barrier to pitting and causing corrosion to occur more uniformly. Silicate inclusions also act as a bond for the corrosion products, and the protective film formed is held tightly by the underlying metal. As a result, wrought iron has a longer service life than carbon steels in most corrosive environments.

Wrought iron is unaffected by refrigerating gases such as ammonia, carbon dioxide and the Freon series, but it exhibits its greatest advantage over low carbon steels when exposed to such environments as salt water, brines and industrial cooling waters. These are conditions commonly encountered in tubular condensers and heat exchangers.

Some comparisons

Many interesting comparisons have been made by those using wrought iron as a replacement for other ferrous materials in such equipment. For example, a chemical company now uses wrought iron tubes in shell-and-tube type heat exchangers handling saturated brine containing 10% ammonia on the shell side and river water on the tube side. Brine enters the heat exchanger at 120-160 F and is cooled to 85-105 F. Wrought iron tubes serve eight years under these conditions; steel tubes fail in three years.

Because wrought iron performs well in handling industrial flue gases, it is widely used in smokestacks and breechings. These applications suggest that cold drawn wrought iron tubing is adaptable to tubular air preheaters and economizers. A power generating plant has investigated the relative durability of various tubular materials in air preheater service by equipping one of its preheaters with alternate tube sections of low alloy steel, enamel coated steel, stainless steel, aluminum, cast iron and wrought iron. Tubes of this preheater are exposed to combustion gases containing 3% sulfur. These corrosive gases caused failure of aluminum tubes in 15 months. After 30 months, low alloy steel, aluminum and cast iron tubes have failed and been removed from service. Enamel coated steel, stainless steel and wrought iron tubes are still giving satisfactory service.

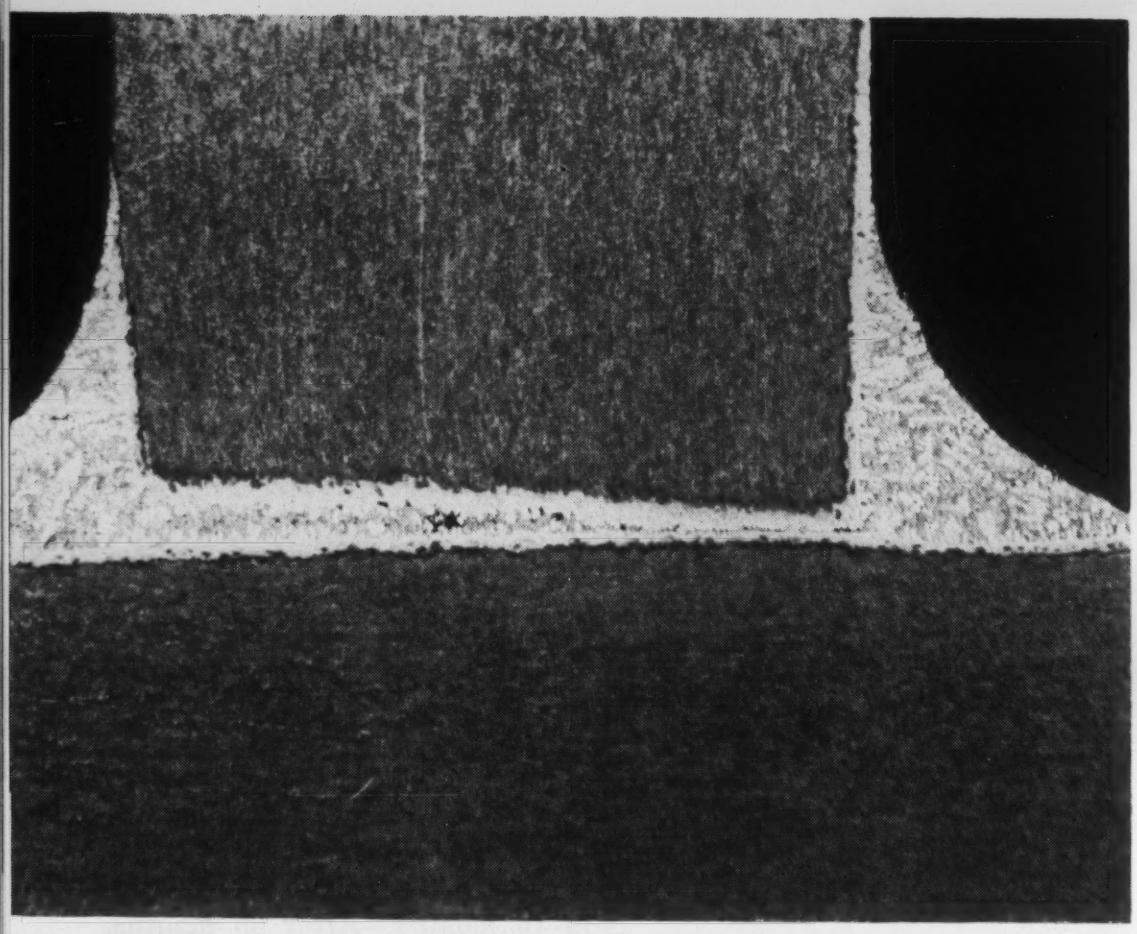
PROPERTIES OF WROUGHT IRON

PHYSICAL PROPERTIES	
Density, lb/cu in.	.278
Ther Cond, Btu/sq ft/ft/hr/°F	34.5
Coef of Ther Exp (212 F), per °F	7.4×10^{-6}
Specific Heat, Btu/lb/°F	0.11
Modulus of Elasticity, psi	29.5×10^{6}
MECHANICAL PROPERTIES	
Long. Yield Point (min), psi	24,000
Long. Tensile Strength (min), psi	40,000
Elongation (8 in.), %	12
Brinell Hardness	97-105

TOLERANCES FOR WROUGHT IRON TUBING AND PIPE COMPARED

Cold Drawn Tubing					Hot Rolled Pipe				
O. D. in.	O. D. Tolerance, in.[a]		Wall Thickness Tolerance, %		Nominal Size, in.	O. D. Tolerance, in.[a]		Wall Thickness Tolerance, %	
	Over	Under	Over	Under		Over	Under	Over	Under
1-1½, incl	0.006	0.003	22	0	1	0.016	0.031	[b]	12½
					1¼	0.016	0.031	[b]	12½
1½-2, excl	0.008	0.004	22	0	1½	0.016	0.031	[b]	12½
2-2½, excl	0.010	0.005	22	0	2	0.024	0.021	[b]	12½
					2½	0.029	0.025	[b]	12½
2½-3, excl	0.012	0.006	22	0	3	0.031	0.031	[b]	12½
3-3½, incl	0.014	0.007	22	0	3½	0.035	0.035	[b]	12½

[a]Including out-of-roundness. [b]Unlimited.



Structure *of a typical joint brazed with aluminum paste filler, showing fillet formation and penetration. Sections are ¼-in., 6061-T6. (14X)*

Joints like this can be obtained by . . .

Dip Brazing with Paste Filler

A new aluminum paste filler is replacing conventional sheet and wire brazing preforms in some dip brazed assemblies.

by Donald E. Wernz and Mel M. Schwartz, *Martin Co.*

■ A new, easily applied paste filler is proving superior in many applications to ordinary sheet and wire fillers used in dip brazing of aluminum parts. Known as Marbraze, the proprietary paste is applied rapidly to joints with a small brush and completely eliminates the need for preformed sheet and wire brazing materials. Because of the ease with which it can be applied, the paste filler has been effective in reducing pre-brazing assembly times as much as 95%.

To date, the new filler has been successfully used with several aluminum casting alloys and

Why the paste is used ➡

14 wrought alloys, including: EC, 1100, 3003, 5050, 5052, 5056, 5254, 6053, 6061, 6062, 6063, 6066, X2219 and X5356. Gap widths up to ⅛ in. can be brazed. Tensile strengths of 40,000 to 45,000 psi have been measured at 1/16 in. brazed joints on 6061 aluminum parts.

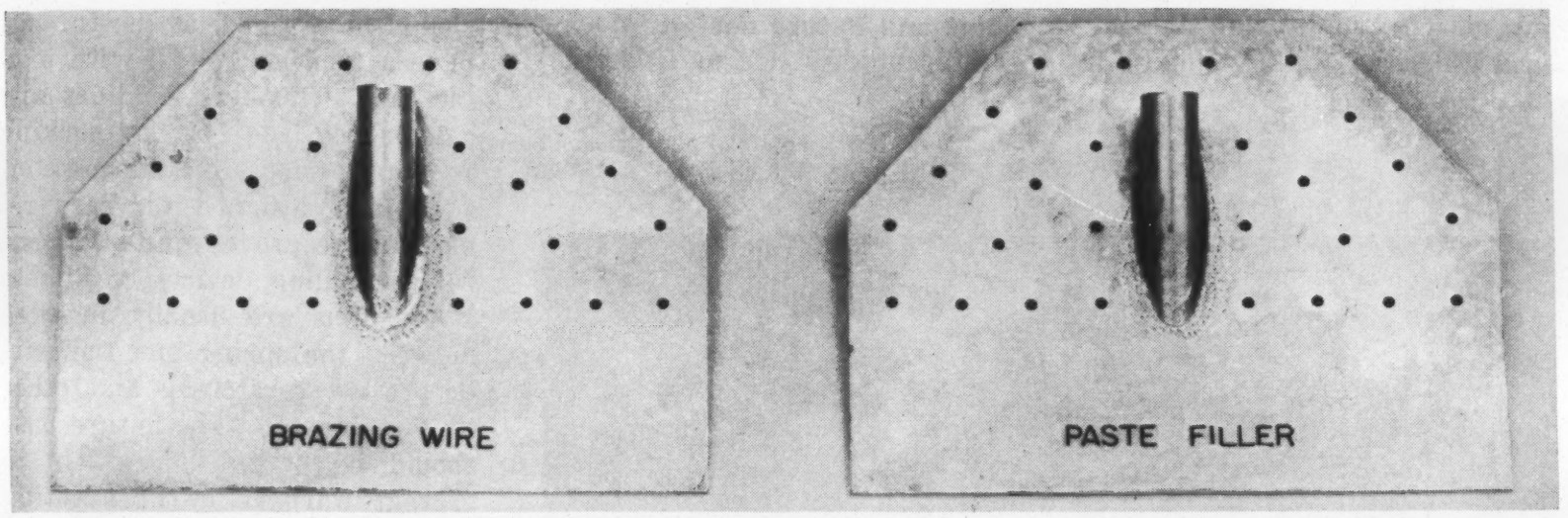
How the paste compares

Conventional filler materials used in the dip brazing process consist of sheet and wire forms. These fillers, made of 718 aluminum, often require considerable shaping and cutting to fit each brazed joint closely. The braze is effected by capillary action or gravity flow of the filler material at 1080 F. Any restriction in flow can produce an imperfect union. (For a complete description of the salt bath dip brazing process, see M&M, Jan '54, p 96.)

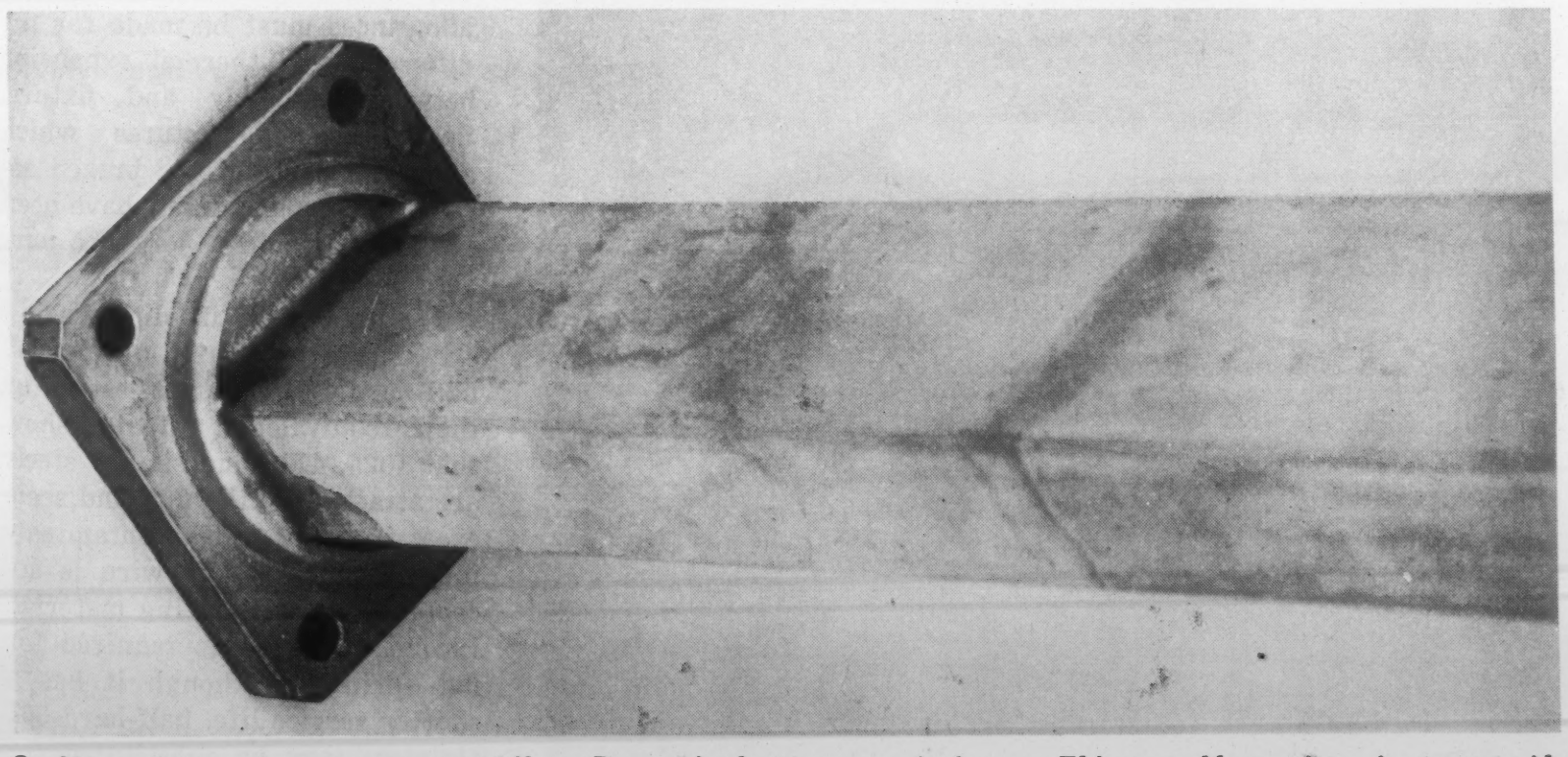
The paste filler, in contrast, is applied in much less time. When it melts it is deposited in a strong, clean union. The resulting fillets are small, smooth and are superior in many respects to sheet or wire fillets.

The filler paste has been used to advantage in many applications. In one design an 18-in. aluminum bar required a square hole to be cut through its entire length. The bar was cut lengthwise and a square slot machined in each half. The halves were then placed together and dip brazed using a conventional sheet

1. It is easy to apply. *Preforming time and cost are eliminated. Part being assembled above is a gas tank fitting.*



2. Fillets are better. *They are smaller, smoother and often stronger than fillets produced by preforms. Note the difference between the two vent fittings above.*



3. It can be used on more assemblies. *Reason is that gaps can be larger. This assembly consists of a wave guide tube and choke flange.*

filler. After being turned to a circular cross section the bar was then threaded along its full length. During the thread chasing operation skips and voids were discovered along the brazed joint. As a result of this imperfection, 22 of the first 30 bars had to be rejected. After switching to the paste filler on the rod halves, however, no rejections occurred after brazing as many as 60 bars.

Brazing procedure

Parts are usually deburred and cleaned prior to brazing, although an acceptable braze with the paste filler can be achieved without these steps. After cleaning, the filler is brushed on the joints, and the parts are assembled in one of several types of brazing fixtures. Tack welds, self-locking joints or various easily removed devices are usually employed to hold the parts in position.

The fixture and assembly are placed in a preheat oven at 1000 F to remove all moisture and prevent heat reduction of the flux bath. After reaching 1000 F the assembly is removed and immediately placed in a furnace containing a molten salt bath of Alcoa No. 34 flux at a temperature not over 1100 F. Immersion time varies from 1 to a maximum of 3 min, depending on the mass of the assembly. The assembly may be subsequently heat treated to obtain maximum strength. After brazing, the assembly is cleaned and brightened by several additional baths and rinses.

Joint and fixture design

Proper joint design is an important element in dip brazing. Self-locating parts eliminate cost and time involved in building elaborate fixtures and considerably reduce assembly times. For most applications joint designs that conform to standard shop tolerances are acceptable. A tolerance of ±0.002 in., however, can be held on joints for waveguide sections and other electronic parts requiring precision assembly.

Tools must be designed specifically for dip brazing. Primary consideration should be given to rapid flux drainage. This reduces the amount of flux "drag-out," lessens the time for flux removal, and aids materially in removing the brazed assembly from the fixture. Use of screws and bolts should be avoided, as the threads have a tendency to fill with molten flux. This flux solidifies and can be removed only by soaking for long periods in boiling water.

Springs designed for easy removal have proved quite successful as holding devices. Stainless steel shims are usually inserted between the spring and the part to prevent scratching and other contact damage. The fixture base should be braced adequately to prevent warpage during heating and cooling. Drilled holes are sometimes used in the fixture to reduce its mass and the preheating time required. Appropriate allowances must be made for the differences in thermal expansion between assembly and fixture. Spring loaded fixtures which allow the parts of the brazed assembly to expand freely have been found satisfactory for this purpose.

Fixtures used in dip brazing are usually fabricated of Inconel, half-hard 301 stainless steel or their equivalents. Tests show that 1025, 4130 and similar steels are attacked by the flux and scale excessively, thereby contaminating the flux. Music wire is acceptable as a coil spring material. Inconel, however, is required for flat springs. Although it has a shorter service life, half-hard 301 stainless may be substituted for Inconel if required.

Wave guide assembly *and fixture being lowered into salt bath.*

St. Regis Paper Co., Panelyte Div.

Representative parts *made from plastics laminates indicate versatility of the materials for industrial applications.*

Selecting Plastics Laminates for Industrial Use

by Malcolm W. Riley, *Associate Editor, Materials & Methods*

This manual will help you select the proper grade of plastics laminate to meet your specific mechanical, electrical or chemical requirements. The materials discussed are high pressure reinforced thermosetting laminates, glass reinforced polyester laminates and vulcanized fibre—all of them available in the form of sheet, rod, tubing and molded shapes.

The discussion includes:

- *Properties*
- *Standards and grades*
- *Combination laminates*
- *Fabrication characteristics*

■ Plastics laminates have extremely high strength-to-weight ratios and good dielectric qualities, coupled with good fabricating characteristics and a high degree of corrosion resistance. Laminate producers adjust these properties over a wide range by altering type and proportion of the component materials or by altering production variables such as temperatures and pressures. Thus, innumerable combinations of physical, mechanical and electrical properties are available to the designer or engineer in standard materials available from stock. This versatility accounts for the great variety of applications for plastics laminates today.

General Properties and Common Forms

Though many factors determine the properties of laminates, it is generally true that mechanical strength is more dependent on the reinforcing material, whereas electrical properties are more dependent on the type and quantity of resin. Table 1 lists typical mechanical, electrical and physical properties for standard grades of laminates.

Of the resin binders used, phenolics are the most common. They are low in cost, have good mechanical and electrical properties, adhere well to fibrous reinforcements and are somewhat resistant to flame.

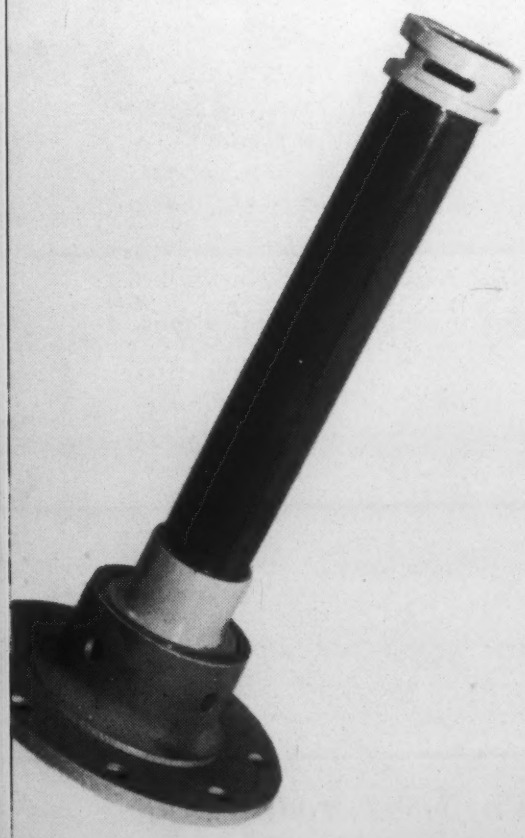
Other resins are used for specific grades to provide improvements in certain properties:

1. Melamines, more costly than phenolics, are used with glass or cotton fabric to provide better resistance to flame, alkalies, arcing and tracking, as well as good colorability.

2. Silicone resins are used with glass cloth to provide high temperature resistance (to about 500 F) combined with good mechanical and electrical properties. They are quite high in cost.

3. Epoxy resins, also costly, are used with glass cloth to provide a high degree of resistance to acids, alkalies and solvents, as well as extremely low moisture absorption. Low moisture absorption permits retention of their inherently high mechanical and electrical properties under humid conditions.

4. Polyester resins, used with glass mat, provide a relatively low cost laminate with relatively good mechanical and electrical properties for general purpose applications.



Taylor Fibre Co.

Chemical resistance, *together with good dielectric and mechanical strength and light weight, caused selection of epoxy-glass laminate tube for this aircraft fuel gage unit.*

Mechanical properties

Tensile strength of vulcanized fibre is about 7000-8000 psi and flexural strength is about double these values. Modulus of elasticity is in 1 million psi range. Tensile strengths of paper, asbestos and cotton fabric-base laminates vary from about 8000 to over 20,000 psi, and flexural strengths are somewhat higher. Moduli of elasticity in tension or flexure are about 1-2 million psi.

Glass, the strongest fibrous reinforcing material, provides tensile strength values in the 13,000 to 37,000 psi range, though glass-reinforced laminates have been prepared with tensile values of over 50,000 psi. Flexural strength is again somewhat higher than tensile values, and modulus of elasticity can approach 3 million psi. Flatwise compressive strength of laminates depends a great deal on compressive strength of the resin. Typical values for most laminates fall in the 20,000 to 50,000 psi range.

A wide range of edgewise impact strengths can be obtained by using different reinforcing materials, and also by altering type of resin. Impact strength for vulcanized fibre is about 3 ft-lb per in. of notch, and paper-base laminates have relatively low values ranging from about 0.25 to 0.90. Values for cotton and asbestos-base laminates range from about 1.0 to 4.5, whereas glass-reinforced laminates provide values from about 4.5 to over 15 ft-lb per in.

Electrical properties

Dielectric strengths perpendicular to laminates (short time test) range from a low of about 175 v per mil for vulcanized fibre to a maximum of 1000 v per mil for a paper-base phenolic. Average values for most other laminates range between 400 and 700 v per mil. Dielectric constants in the as-received condition range between 3.3 and 7.0, whereas dissipation factor (condition A—as received—at 10^6 cycles) ranges from a high of about 0.055 for cotton fabric-base phenolic lami-

nates to a low of about 0.0015 for a glass-reinforced silicone laminate.

Physical properties

Retention of dielectric properties of laminates used in humid or moist environments depends on the water absorption characteristics of the laminate. The extreme susceptibility of vulcanized fibre to moisture was one important reason for development of reinforced thermosetting laminates. For 1/16 in. thick reinforced laminates, moisture absorption values range from a high of about 6.0% (increase in 24 hr for a 1 x 3-in. specimen) for a phenolic laminate with low resin content to a low of about 0.09% for an epoxy grade. Though each resin varies in moisture absorption characteristics, moisture absorption for a given laminate generally decreases as resin content increases, regardless of resin type. Typical values for standard laminates with relatively good moisture absorption characteristics range between 0.3 and 1.3% increase in 24 hr for 1/16 in. thicknesses. Over-all absorption values decrease as laminates increase in thickness.

Heat resistance of laminates depends on the type of resin and reinforcement. Most standard laminate grades are designed for AIEE Class A or B insulation requirements, though there are two standard Class H silicone laminates. Maximum continuous heat resistance of laminates is about 200 F for vulcanized fibre, 250 F for phenolics reinforced with organic materials, 300 F for phenolics, melamines and epoxies reinforced with inorganic materials, and 500 F for silicones that are reinforced with inorganic materials.

Flame retardance of most standard grades of laminates other than melamines is relatively poor, and in many cases where this property is incorporated in special grades, other properties suffer. There is a great deal of promising development work now under way aimed at improving flame resistance characteristics of resins without sacrificing either their mechanical or electrical properties.

Chemical properties

In general, plastics laminates resist corrosive solutions and atmospheres such as acids, alkalies, solvents, salts and salt solutions. Of the resin binders, phenolics have good resistance to most of these environments, melamines have better resistance to alkalies, and epoxy resins provide the maximum in chemical resistance.

Cotton fabric-base is satisfactory for weak acids, weak bases, most salt solutions and organic solvents. Asbestos-base is resistant to alkaline solutions but is not recommended for acid solutions. Glass-base is recommended for strong concentrations of acids or acid salts.

In selecting specific grades for severe types of chemical service, producers' recommendations should be observed.

Common forms

Plastics laminates can be specified and purchased from stock in the form of sheets, rod and rolled or molded tubing. Laminated shapes can also be specified; these are generally custom molded by laminate producers.

Vulcanized fibre rod and tubing have the same characteristics and general properties as vulcanized fibre sheet, though they are slightly more dense. Rods are machined from sheet stock and ground to size. Tubes are produced by winding chemically treated paper on stainless steel mandrels, then drying, rolling and grinding.

Reinforced rod usually has the same properties as corresponding grades of sheet, except for a commonly encountered low density area in the center of the rod. Property values can also be slightly lower than corresponding sheet grades because of the "lay" of the lamina. Rods are usually produced by rolling impregnated reinforcements onto a mandrel, removing the mandrel and compressing the stock in a mold under

Plastics Laminates: What They Are

Laminates discussed in this manual are of two basic types: 1) reinforced thermosetting plastics and 2) vulcanized fibre, They are grouped here because of the similarity in the types of applications for which they are used.

Reinforced laminates are produced by impregnating a reinforcing material with a thermosetting resin, laminating the material into multiple layers, and curing with heat and pressure to form a dense, hard solid with good mechanical strength. Pressures used for forming most laminates are about 1000 psi or more. (Some laminates, such as Grade GPO-1 glass-polyester, use lower pressures on the order of 200 to 300 psi.) Reinforcements used in making high pressure laminates include cellulose paper, cotton fabric or mat, glass cloth or mat, asbestos paper or fabric, and nylon fabric. Resins used include phenolic, melamine, silicone, epoxy and polyester,

Vulcanized fibre is a laminated plastic with only one component: cellulose (see M&M, Sept '54, p 110). It is made by laminating chemically gelled paper, leaching out the chemical, and calendering. The resulting laminate is tough and hornlike, and has good electrical properties. It consists of partially regenerated cellulose in which the fibrous structure is retained in varying degrees, depending on the grade of fibre.

In addition to the industrial laminates discussed here, there are decorative laminates, which provide a wide range of colors and designs for uses such as furniture, kitchen appliances, walls and similar types of applications. In some of these laminates the decorative effect is incorporated directly into the laminate, and in some the decoration is applied as a veneer. Because of space limitations, these laminates are not covered in this manual.

TABLE 1—TYPICAL PROPERTIES

Grade	Mechanical Laminates									
	X	P	PC	ES-1, 2, 3	C	L	MC	Bone Fibre	XX	XXP
Comparative Cost[a]	0.7	0.8	0.8	—	1.4	1.7	1.6	0.4	1.0	1.0
MECHANICAL PROPERTIES										
Tensile Strength, 1000 psi										
Lengthwise	**20**	12	10.5	12-15	11	14	11	8	16	11
Crosswise	**16**	9	8.5	8-12	9	10	7	6	13	8.5
Flexural Strength, 1000 psi										
Lengthwise	**28**	15	14	15	**22**	23	23	15	18	18
Crosswise	**23**	13	11	15	**18**	18	18	13	14	14
Compressive Strength (flatwise), 1000 psi	**36**	25	22	—	37	35	45	30	34	25
Modulus of Elasticity in Flexure, 10^5 psi										
Lengthwise	**18**	12	10	—	10	11	—	**12**	14	9
Crosswise	**13**	9	8	—	9	8	—	**8**	11	7
Edgewise Impact Strength, ft lb/in. notch										
Lengthwise	**0.9**	0.8	0.9	0.25	**2.3**	1.3	0.9	**3.0**	0.55	0.55
Crosswise	**0.7**	0.6	0.8	0.22	**2.2**	1.2	0.9	**2.4**	0.50	0.50
Rockwell Hardness										
(M scale except where designated)	110	95	75	118	103	105	115	**R80**	105	100
Bond Strength, lb	900	—	—	—	**2000**	1700	1900	—	1100	—
ELECTRICAL PROPERTIES										
Dielectric Strength (perp, short time), v/mil										
1/16 in. thick	700	650	600	—	500	500	—	175	700	700
1/8 in. thick	500	470	425	—	360	360	—	150	500	500
Dielectric Strength (par., step by step, 1/8 in. thick), kv										
Cond A	—	50	—	—	15	15	—	—	50	65
Cond D48/50	—	10	—	—	—	—	—	—	10	15
Dissipation Factor (10^6 cycles)										
Cond A	—	—	—	—	—	0.055	—	—	0.040	0.037
Cond D 24/23	—	—	—	—	—	0.070	—	—	0.046	0.045
Dielectric Constant (10^6 cycles, cond A)	—	—	—	—	6.0	5.8	—	—	5.3	4.5
Insulation Resistance, (cond C96/35/90), megohm	—	—	—	—	—	—	—	—	60	500
Arc Resistance, sec	10	—	—	—	10	10	**100**	100	10	10
AIEE Insulation Class	A	A	A	A	A	A	—	—	A	A
PHYSICAL PROPERTIES										
Density, gm/cu cm	1.35	1.33	1.34	—	1.35	1.34	1.5	1.3	1.34	1.32
Ther Cond, Btu/sq ft/hr/°F/ft	0.17	0.17	0.17	—	0.17	0.17	0.17	0.17	0.17	0.17
Heat Resistance, °F										
Short Time	275	275	250	—	275	275	275	—	300	275
Continuous	225	250	200	—	225	225	225	221	250	250
Coef of Ther Exp, per °F, x 10^{-5}										
Lengthwise	0.61	0.43	—	—	0.58	0.43	—	—	0.41	0.58
Crosswise	0.77	0.68	—	—	0.68	0.58	—	—	0.74	0.92
Water Absorption, % in 24 hr										
1/16 in. thick	4.0	2.2	3.2	2.5	4.4	2.0	2.2	55	**1.3**	**1.3**
1/8 in. thick	2.3	1.5	2.0	1.8	2.5	1.4	1.6	48	**0.9**	**0.9**
1/2 in. thick	0.9	—	—	—	1.2	0.8	1.0	25	**0.5**	—

[a] Properties given are average values and do not reflect NEMA limiting values. Bold face numbers indicate exceptionally significant property values to be used for initial screening of laminates. Subsequent comparison of other properties forms basis of selection of proper grade.

high pressure and temperature. Some grades of rod are produced by centerless grinding from sheet stock.

Properties of reinforced rolled or molded tubing (see Table 2) differ somewhat from those of corresponding sheet grades. Rolled reinforced tubing is generally more concentric than molded tubing but has a slightly higher moisture absorption rate. It also has higher dielectric strength, lower power factor and lower dielectric constant than molded tubing. Rolled reinforced tubing is produced by rolling resin-impregnated reinforcing material on a

OF HIGH PRESSURE LAMINATES[a]

Electrical Laminates								General Purpose Laminates (Mechanical-Electrical)							
XXX	XXXP	LE	G-2	G-6	G-7	N-1	Electrical Insulation Fibre	CE	A	AA	G-3	G-5	G-10	GPO-1[c]	Commercial and Trunk Fibre
1.1	1.2	1.7	2.9	6.7	6.7	3.7	0.4	1.4	1.1	2.7	2.7	2.4	3.7	0.9	0.4
15	12	13.5	16	13	**23**	8.5	7.5	11	10	12	**23**	**37**	—	12	7.5
12	9.5	9.5	11	10	**18**	8	5.5	9	8	10	**20**	**30**	—	10	5.5
18	21	18	30	23	**44**	18	—	**22**	20	21	**32**	**65**	**72**	23	14
14	15	15	20	19	**37**	15	—	**17**	18	19	**28**	**50**	**63**	20	12
32	25	37	38	40	**45**	—	32	**39**	40	38	50	**70**	—	40	20
13	11	10	13	—	**14**	6	—	9	23	16	15	**17**	—	15	—
10	8	8	10	—	**12**	5	—	8	14	14	12	**15**	—	13	—
0.5	0.6	**1.3**	6.6	**15.1**	**12.1**	3.7	—	**1.6**	1.0	**4.5**	**7.5**	**12.0**	**14.4**	12	3.5
0.45	0.5	**1.2**	4.7	**9.5**	**9.6**	3.3	—	**1.4**	0.9	**4.0**	**6.0**	**9.0**	**10.6**	10	2.9
110	112	105	110	95	100	105	—	105	111	103	120	**120**	—	100	R50
1200	—	1800	1400	1000	800	1200	—	2200	800	2000	1000	**1700**	**2500**	1000	1000
650	650	500	500	250	**400**	600	**175**	500	225	85	**700**	350	**810**	650	175
470	470	360	425	185	**350**	450	**175**	360	160	70	**600**	260	**570**	500	150
65	65	50	30	50	55	62	—	45	10	—	—	32	**55**	60	—
15	33	6	10	45	30	55	—	5	—	—	—	12	**60**	33	—
0.034	**0.030**	0.048	**0.025**	**0.0022**	**0.0015**	**0.024**	—	0.055	—	—	**0.030**	0.016	**0.0119**	0.03	0.024
0.038	**0.035**	0.058	**0.080**	**0.0227**	**0.0150**	**0.030**	—	0.070	—	—	—	0.030	**0.0126**	0.06	0.030
4.7	4.27	5.3	5.5	4.18	3.9	**3.3**	—	5.3	—	—	6.5	6.8	4.8	**4.3**	—
1000	**20,000**	30	5000	**4000**	2500	**5 x 10^4**	—	—	—	—	—	200	100	**1 x 10^5**	—	—
10	10	10	—	**220**	**220**	—	100	10	10	10	10	**200**	17	100	100
A	A	A	B	H	H	A	A	A	B	B	B	B	B	B	—
1.32	1.32	1.32	—	1.65	1.68	1.15	1.15	1.32	1.72	1.70	1.65	1.9	1.78	1.5-1.9	1.15
0.17	0.17	0.17	—	0.17	0.17	—	—	0.17	—	—	—	0.29	—	—	—
300	275	300	410	**500**	**500**	200	—	300	**400**	**400**	410	**425**	350	350	—
250	250	250	290	**400**	**400**	165	—	250	**275**	**275**	290	**300**	250	250	—
0.41	0.58	0.58	—	0.31	—	—	—	0.58	0.31	0.58	0.52	0.31	—	1.1	—
0.71	0.92	0.80	—	0.31	—	—	—	0.68	0.49	0.58	0.62	0.34	—	—	—
0.8	**0.40**	**1.3**	1.50	**0.3**	**0.3**	**0.3**	66	**1.3**	1.3	2.5	1.8	1.0	**0.09**	1.0[b]	66
0.5	—	**0.8**	0.95	**0.25**	**0.20**	**0.2**	61	**0.9**	0.8	2.0	1.2	0.6	**0.06**	0.70[b]	61
0.3	—	**0.5**	0.55	**0.15**	**0.15**	**0.1**	36	**0.5**	0.5	1.2	0.7	0.4	**0.03**	0.35[b]	36

[b] Maximum values. [c] Although NEMA classifies GPO-1 as a general purpose grade, primary uses at present are electrical.
[d] Based on arbitrary value of 1.0 for Grade XX. Figures should be used for comparison purposes only.

mandrel under heat, tension and pressure, then oven-curing.

Molded reinforced tubing, in addition to lower moisture absorption, generally has greater mechanical strength than rolled tubing. Dielectric strength of molded tubing may be low at mold seams, particularly in thin walls. Molded tubing is produced by rolling resin-impregnated reinforcing material on a mandrel under heat and pressure, then curing in a mold under high pressure and temperature.

In addition to cylindrical rod and tubing many special shapes, such as square or rectangular rod

TABLE 2—TYPICAL PROPERTIES OF REINFORCED

NEMA Grade		Density	Tensile Strength, 1000 psi	Compressive Strength (axial), 1000 psi	Dielectric Constant (10^6 cycles)	Dielectric Strength (short time, perp), v/mil — Wall Thickness, in.					Water Absorption, % in 24 hr — Wall Thickness, in.		
						1/16	Over 1/16 to 1/8	Over 1/8 to 1/4	Over 1/4 to 1/2	Over 1/2 to 1	1/16	1/8	1/2
PAPER-BASE	X	**1.25** 1.10	**12** 8.5	**18** 10	— —	— 400	**270** 290	**180** 200	**100** 145	— 120	**4.5** 5.0	**3.6** 4.0	— 2.4
	XX	**1.25** 1.10	**11** 8	**18** 11	**5.5** 5.0	**300** 400	**220** 290	**150** 200	**110** 145	— 120	**1.8** 3.0	**1.6** 2.0	**0.9** 0.7
	XXX	**1.22** —	**9** 10	**20** 20	**5.5** 4.4	**300** 500	**220** 400	**150** 300	**110** 250	— —	**1.2** 1.4	**1.0** 1.1	**0.7** 0.8
COTTON FABRIC-BASE	C	**1.25** 1.12	**9** 6	**19** 12	— —	— —	**160** 175	**110** 125	**75** 90	— —	**3.5** 5.0	**2.2** 3.0	**1.3** 0.8
	CE	**1.25** 1.12	**8.5** 6	**19** 13	— —	— —	**175** 180	**125** 130	**90** 100	— —	**3.0** 4.7	**2.0** 2.7	**1.1** 1.3
	L	**1.25** 1.12	**9** 6	**18** 12	— —	— —	**160** 160	**110** 110	**75** 75	— —	**3.5** 5.0	**1.8** 2.8	**1.6** —
	LE	**1.25** 1.12	**8.5** 7	**19** 13	— —	**150** 150	**175** 170	**125** 120	**90** 85	— 70	**2.2** 4.5	**1.5** 2.5	**1.2** 1.2
ASBESTOS-BASE	A	**1.55** 1.25	**10** 7	**18** 10	— —	— —	**85** 90	**70** 75	**55** 60	— —	**2.0** 2.2	**1.6** 1.8	— —
	AA	**1.55** —	**9** —	**18** —	— —	— —	**90** —	**75** —	**60** —	— —	**2.0** —	**1.6** —	— —
GLASS-BASE	G-3	**1.55** 1.50	**30** 25	**20** 13	— —	— —	**170** 175	**120** 125	**85** 90	— —	**3.7** 4.0	**3.0** 3.2	— —
	G-5	**1.8** 1.7	**30** 25	**20** 13	— 7.0	— 225	**155** 160	**105** 110	**75** 80	— 80	**4.3** 4.5	**3.2** 3.5	— 2.2
	G-7	— 1.6	— 20	— 10	— 3.7	— 225	— 200	— 150	— —	— —	— 0.7	— 0.5	— —
NYLON-BASE	N-1	**1.15** —	— 5	— 18	— —	— 400	— 200	— —	— —	— —	— 0.8	— 0.8	— —

[a] Bold faced values are for molded tubing; light faced figures for rolled tubing. Bold face type in "Principal Characteristics and Uses" column indicates outstanding characteristic.

and tubing, are available from stock. Properties of such shapes are similar to those of cylindrical rod and tubing except as limited by their geometry. Likewise, properties of parts molded to specification by laminate producers are generally similar to those of corresponding sheet grades.

Standards and grades

Since the laminate is one of the oldest forms of plastics materials, relatively comprehensive standards have been developed. The most comprehensive industry-wide standards are those established by NEMA (National Electrical

LAMINATED TUBING[a]

Principal Characteristics and Uses	Special grades are available with . . .
Excellent mechanical strength, fair machinability, fair electrical properties under dry conditions	—
General purpose uses requiring good strength, resistance to moisture, good acid resistance and good electrical properties	1) Greater toughness at some sacrifice in dimensional stability and electrical properties at high humidity. 2) High burst strength. 3) Maximum dimensional stability for small bushings. 4) Good 60 cps power factor. 5) Melamine binder for greater resistance to flame and arcing
Low moisture absorption and low dimensional change. Best electrical grade of molded tubing	—
Low moisture absorption and good electrical properties	Coarser-weave reinforcements for general purpose mechanical applications where high impact strength is critical
Electrical applications requiring **good strength and machining characteristics**	1) Higher electrical properties. 2) Better acid and alkali resistance. 3) Higher burst strength or higher longitudinal strength. 4) Finer weave reinforcement for optimum machining
Fine weave cotton reinforcement for **mechanical** uses requiring **good machinability**	1) Improved chemical resistance. 2) Graphite filler for antifriction properties. 3) Melamine binder for flame and arc resistance
Standard fine weave **electrical grade with better machinability** than C, CE or L. Not as tough as CE	Bleached and purified fiber for better machining and dimensional stability
Low dimensional change in moisture. Used for applications requiring **resistance to flame and heat**	Melamine binder in molded tube for improved resistance to heat and arcing
Used for mechanical applications requiring **high strength, good dimensional stability, resistance to heat and flame** and good wearing qualities	1) Improved chemical resistance. 2) Melamine binder for improved heat and arc resistance
Continuous filament glass cloth-base laminate used for **mechanical applications** requiring fair heat resistance	Staple fiber glass reinforcement in rolled or molded tubing with either phenolic or melamine binder. Such grades are lower in cost, much weaker mechanically
High mechanical strength, good flame resistance, good arc resistance and good electrical properties at high frequencies under dry conditions. Difficult to machine	—
Maximum heat resistance and excellent electrical properties at high frequencies, wet or dry. Poor bond strength. Difficult to machine	Better high temperature electrical properties at some sacrifice of mechanical properties
Very low water absorption and good electrical properties. Heat resistance limited because of thermoplasticity of nylon reinforcement	—

Manufacturers' Assn.) covering 25 grades of industrial thermosetting reinforced laminates and four grades of vulcanized fibre. These standards, readily available from NEMA, establish maximum or minimum properties that must be met by proprietary laminates marketed as conforming to NEMA standard grades. (Military, Federal and ASTM specifications pertaining to laminates can be found in MATERIALS & METHODS, Nov '54, p 131.) Most property values given in this manual are not limits but are typical values obtainable in proprietary laminates.

In addition to standard grades, innumerable special grades have been developed by various laminate producers. These grades either have property values that fill gaps between those of standard grades, or have combinations of properties designed to meet specific design requirements.

To aid in classifying laminates the individual grades discussed in the following pages are grouped into Mechanical, Electrical and General Purpose (Mechanical-Electrical) types. Where applicable, the description of a standard grade is followed by a description of the types of special grades available, these special grades being modifications of the standard grades with which they are grouped. The discussion of special grades below pertains primarily to sheet grades; special grades of tubing are described in Table 2. Because of the number of special grades and the variety of combinations of properties obtainable, the descriptions are qualitative. Specific property data should be obtained from producers.

In general, mechanical grades are relatively inexpensive, good in mechanical strength and undistinguished in electrical properties. Electrical grades, usually more expensive, have been developed specifically for high dielectric properties, but have relatively good mechanical strength as well. General purpose grades, which include some of the most expensive laminates available, have optimum combinations of electrical and mechanical properties and are designed for use where both electrical and mechanical requirements are critical. This group includes G-5 which is the strongest of the standard laminates, and G-10 which has the highest insulation resistance of the standard laminates.

Mechanical Grades

There are ten standard NEMA grades intended primarily for mechanical use: six paper-base phenolics, two cotton fabric-base phenolics, one cotton fabric-base melamine, and Bone vulcanized fibre.

Grade X

This material consists of high strength kraft paper with a low phenolic resin content. It has the best impact strength of the paper-base laminates, though values are not as high as those of fabric-base grades. Minimum edgewise values are about 0.55 ft lb per in. of notch; typical values are about 0.9 ft lb per in. lengthwise and 0.7 crosswise.

Grade X laminates should be used with discretion where high humidity conditions are encountered, since the low resin content results in relatively high water absorption. Drilling or tapping parallel to laminations is not recommended.

Special grades have been developed to improve punching characteristics, to allow postforming, to provide flame resistance, to add strength and to lower cost. Though Grade P is the standard punching laminate, punchable Grade X laminates are available with greater flexibility than Grade X and with higher strength than Grade P. Postforming grades are available with crepe paper reinforcement impregnated with special aniline type resins. Other modified laminates provide improvements in tensile and flexural strength on the order of 1000-2000 psi and 2000-3000 psi respectively. Improvements in heat resistance raise maximum temperature limits about 25 °F.

Grade P

This grade is a paper-base, plasticized phenolic laminate suitable for hot punching (200-250 F) in thicknesses up to and including 1/8 in., and cold punching in thicknesses up to and including 1/16 in. It is more flexible but not as strong as Grade X, and it has relatively good dielectric properties under dry conditions. Because of its lower water absorption it can withstand humid conditions better than Grade X, but it does not have the dimensional stability of Grades XXP or XXXP. Drilling and tapping parallel to laminations is not recommended.

Special grades have been developed with improved dimensional stability and intermediate hardness. Also available are so-called "warm punching" grades which require temperatures of only about 175-200 F for good punching.

Grade PC

Grade PC is a paper-base phenolic laminate with properties similar to those of Grade P, but intended for cold punching applications. It has higher cold flow and flexibility, but slightly lower flexural strength, than Grade P. It can be cold punched and sheared in thicknesses up to and including 1/8 in.

Grades ES-1, 2, 3

These are paper-base laminates used for engraving stock or similar applications. ES-1 is usually a melamine laminate with a black or gray surface and a white core. ES-2 is usually a phenolic laminate and has a black or gray surface, a white subcore and a black core. ES-3 usually consists of a black phenolic core with a white or gray melamine surface.

Special grades have been developed to provide a wider range of decorative effects. In addition to standard colors, laminates are available with a variety of simulated wood finishes, including walnut, autumn walnut, natural maple and natural oak.

Grade C

This material is a cotton canvas-base phenolic laminate intended for applications requiring toughness and high impact strength. Typical edgewise impact values of 2.3 ft-lb per in. notch fall between those of Bone vulcanized fibre and Grade L laminates. The fabric used weighs *over* 4 oz per sq yd and has a count of not more than 72 threads per in. in the fill direction and not more than a total of 140 threads per in. in both the warp and fill directions.

The heavier the fabric base the higher the impact strength, but the rougher the machined edge. Thus, there can be several subgrades in this class adapted for various types of mechanical service, e.g., various sizes of gears.

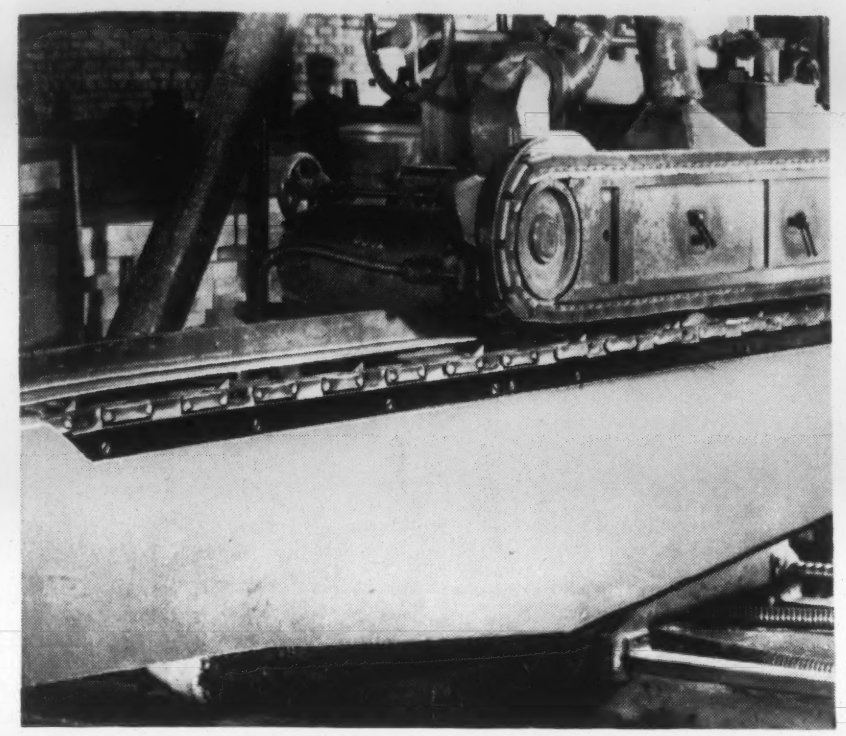
Special grades are available in a range of fabric weights suitable for specific applications, such as gears with certain pitches and applications where requirements such as bond strength or attractive machined surfaces are vital. Finer weave fabrics are used for highly machinable grades.

Other special grades include: 1) a postforming grade with non-afterglow characteristics, 2) minimum odor grades for food processing equipment, 3) grades in which electrical characteristics have been improved somewhat at a sacrifice in mechanical strength, i.e., mechanical properties are not as good as those of Grade C, and electrical properties are not quite equal to those of Grade XX, 4) grades bonded with melamine resin to improve resistance to caustics, flame, heat and arcing, 5) abrasion resistant grades heat treated for greater hardness, impact strength and fatigue strength, and 5) grades which contain graphite or molybdenum disulfide to reduce friction and wear in bearing applications.

Grade L

Grade L is a fine weave, cotton linen-base phenolic laminate intended for mechanical uses where a fine machined appearance is desirable. The fabric weighs *not over* 4 oz per sq yd, with a minimum count of 72 threads per in. in any ply in the fill direction and 140 threads per in. in both the warp and fill directions. It has higher tensile but lower flexural and impact strengths than Grade C. It is recommended particularly for fine gears and other intricate machining applications.

Good mechanical properties make laminates useful for . . .

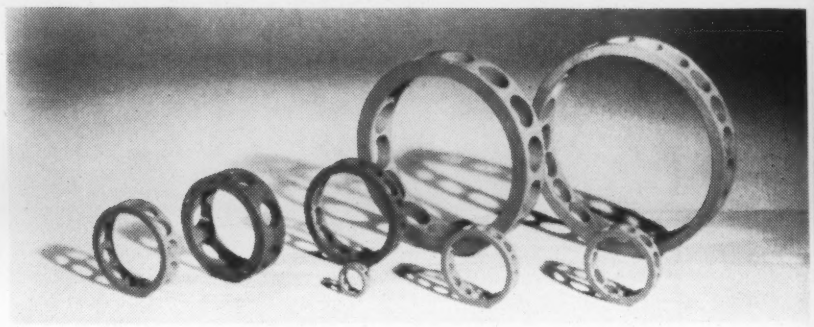


Farley & Loetscher Mfg. Co.

***Ways** for a double end tenoner (used for machining wooden tenons). Grade C laminate replaced brass, eliminating lubrication, increasing life 25-40% and shortening cutting cycles. Section of way is shown at bottom.*

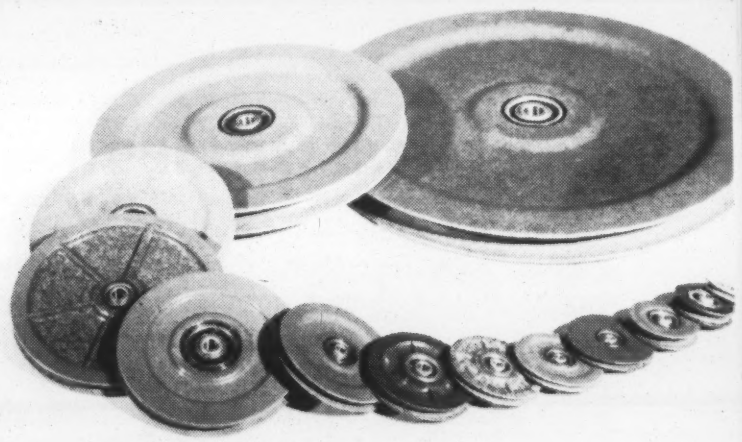
Formica Co.

***Table tennis** racket, made of ¼ in. thick Grade C laminate (plus wood handle and rubber grip). This canvas-base grade has the necessary impact and flexural strength and good machinability.*



Micarta Div., Westinghouse Electric Corp.

***Retainer rings** for ball bearings, which are machined from laminated tubing.*



Micarta Div., Westinghouse Electric Corp.

***Molded pulleys.** Made of cotton-base laminates, they have properties similar to those of corresponding grades of flat sheets.*

Special grades are available heat treated for greater hardness and abrasion resistance. Such grades have good wear and corrosion resistance qualities and present a better machined appearance than heat treated Grade C laminates. Other special grades include: 1) grades containing graphite or molybdenum disulfide for bearing applications, grades with increased resin content to improve electrical characteristics, and 3) grades with improved resistance to flame, heat and arcing.

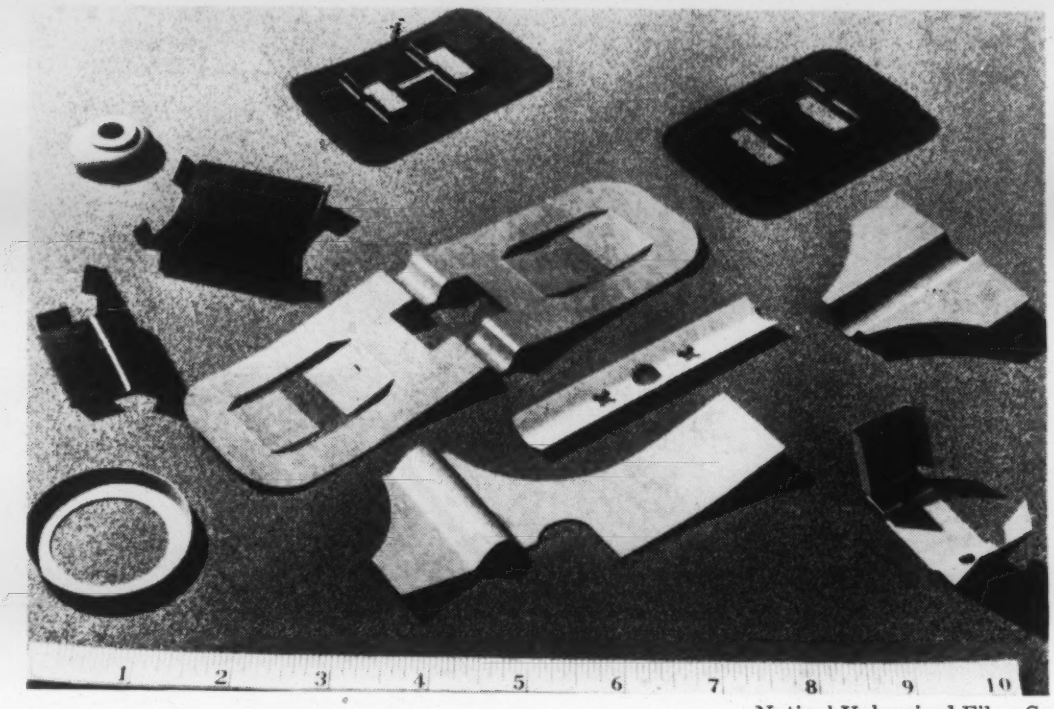
Grade MC

This is a specialty grade made from purified cotton fabric with a melamine resin binder. It is intended primarily for use in plating barrels and has high alkali and arc resistance.

Bone

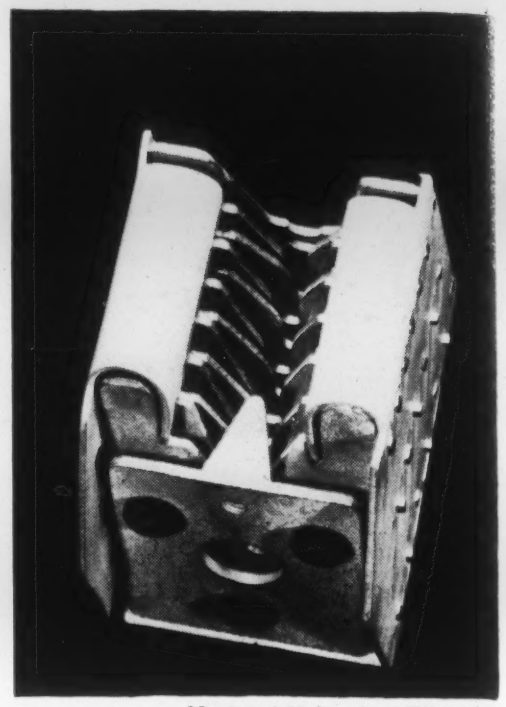
This material, the hardest grade of vulcanized fibre, is intended for mechanical applications where stiffness, high strength, and resistance to wear and abrasion are critical. Rated the most machinable of the fibre grades, Bone is particularly well suited for applications where difficult machining is required and a good surface is desirable. It is not as suitable for bending as Commercial Grade vulcanized fibre.

Good electrical properties make laminates useful for . . .



Nationl Vulcanized Fibre Co.

Insulation *for pole pieces in household electric meters (two parts at top). All of the insulating parts shown here are made of vulcanized fibre (fish paper).*



National Vulcanized Fibre Co.

Circuit breakers arc chute, *which makes use of the high arc resistance, dielectric strength and low cost of Bone fibre.*

Electrical Grades

The ten standard electrical grades have excellent dielectric qualities, and though mechanical properties are relatively good they are secondary in importance. Electrical grades include four paper-base phenolic laminates; one cloth-base phenolic; three glass-base laminates—one a phenolic, the other two silicones; a nylon-base phenolic laminate; and Electric Insulation Grade vulcanized fibre.

Grade XX

This grade is a paper-base phenolic laminate intended for general purpose electrical applications. It has high dielectric strength, which is retained relatively well after exposure to high humidity. It has good dimensional stability and moderate mechanical strength coupled with good machining characteristics.

Special grades which can be postformed are available. Other special grades include: 1) grades that are very hard and resist cold flow better than Grade XX, 2) melamine-bonded grades with mechanical and electrical properties similar to those of Grade XX, but with greater resistance to heat, flame and arcing, 3) flame resistant grades which meet tentative Underwriters' specifications, and 4) minimum odor grades for food processing equipment.

Grade XXP

Grade XXP is a paper-base phenolic laminate suitable for hot punching (200-250 F) and having better moisture resistance and electrical characteristics than Grade XX. It has high insulation resistance and low dielectric losses under severe humidity conditions. It is intermediate between Grades P and XX in cold flow resistance and punching characteristics.

Special grades with higher heat resistance are available for use in coated resistor strip applications. These grades are designed to resist oven temperatures required to cure the coatings.

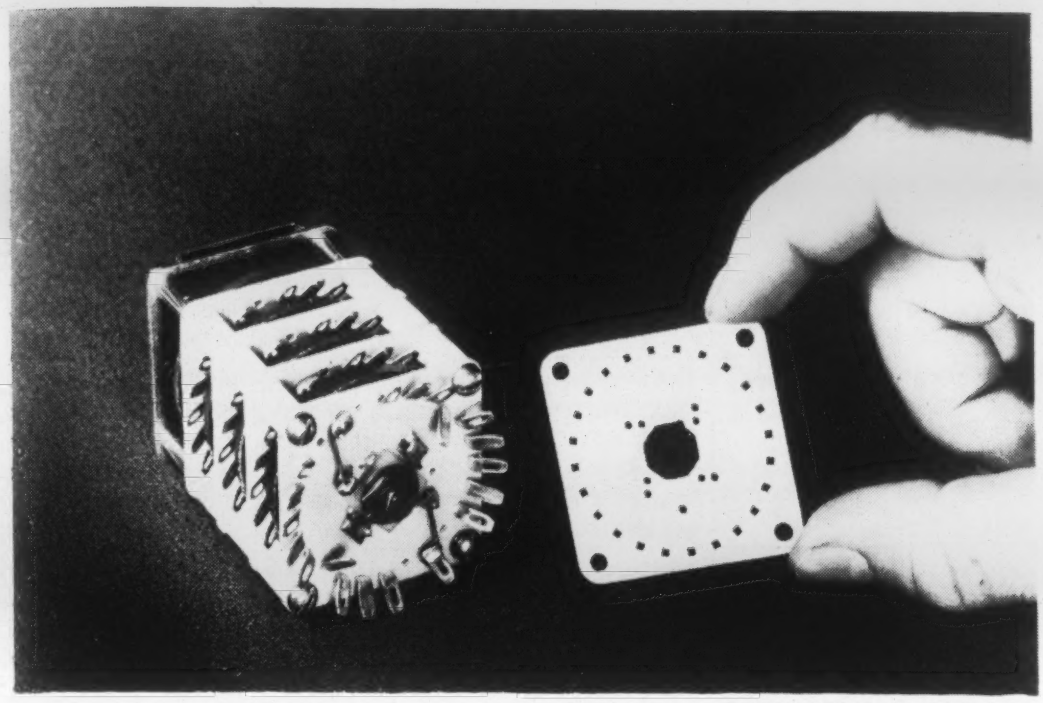
Grade XXX

This is a paper-base laminate with a high phenolic resin content, providing good electrical properties, low moisture absorption, and low cold flow under high humidity conditions. It is particularly well suited for high voltage and high (radio) frequency applications. It has good machining characteristics. Mechanical strength properties are similar to those of Grade XX.

Special grades are available with better cold flow resistance. Other grades have higher dielectric strength parallel to laminations at fairly high temperatures, and low or dissipation factor at 60 cycles.

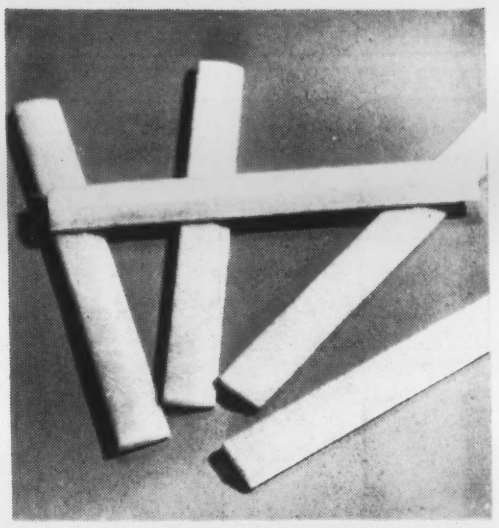
Grade XXXP

This paper-base laminate contains a plasticized phenolic resin to permit hot punching. It has better dielectric properties than Grade XXX and is intermediate in punching characteristics between Grades XXP and XX. It is



National Vulcanized Fibre Co.

***Decks** in miniature precision rotary switch. Material is Grade G-7 glass-silicone laminate, selected because of its resistance to heat and moisture. Tolerances on punched holes are ± 0.005 in.*



Insulation Manufacturers Corp.

***Motor slot wedges** which must combine hardness, toughness and mechanical strength with dielectric strength, moisture resistance, uniformity, ease of machining and relatively low cost. These wedges are made of polyester-glass laminates for Class B use.*

particularly recommended for applications requiring high insulation resistance and low dielectric losses under severe humidity conditions.

Special grades include: 1) grades with better punching characteristics at lower temperatures, 2) cold punching and shearing grades which have lower mechanical properties than Grade XXXP but equivalent electrical characteristics, and 3) grades with higher insulation resistance.

Grade LE

Grade LE is a cotton linen-base phenolic laminate recommended for electrical applications requiring greater toughness than Grade XX provides, and better machining properties and finer appearance in thinner sizes than Grade CE provides. It is not recommended for primary insulation. It can be hot punched in thin sizes.

Special grades include gear stock intended for fine tooth gears with pitches higher than 40, and grades with better resistance to acids and alkalies.

Grade G-2

This material is a staple fiber, glass cloth-base phenolic laminate with good electrical properties under high humidity conditions. It is lower in dielectric losses than other glass-base grades except the silicone laminates. Mechanically it is the weakest of the glass-base grades, though it has good dimensional stability.

Grade G-6

This continuous filament, glass cloth-base silicone laminate is recommended for high temperature (Class H) insulation. It has good electrical properties under humid conditions, but extremely good dielectric loss and insulation resistance characteristics under dry conditions. Arc resistance is excellent. Dimensional stability and impact strength are high, whereas other mechanical properties are only fair.

Grade G-7

Grade G-7 is a continuous filament, glass cloth-base silicone laminate combining the thermal and electrical properties of Grade G-6 with higher tensile and flexural strengths. It is second only to Grade G-5 in flame resistance.

Special grades include: 1) grades with a softer resin binder to reduce crazing on exposure to high temperatures, 2) grades with higher insulation resistance and dielectric strength under humid conditions, and 3) lower cost grades, achieved by using a coarser weave of glass cloth.

Grade N-1

This nylon fabric-base phenolic laminate has exceptionally high insulation resistance and excellent electrical properties under high humidity conditions. It has good impact strength and is easy to machine and punch. It is post-formable, but has poor resistance to cold flow and suffers severe decreases in flexural strength at temperatures above 165 F due to the thermoplasticity of the nylon reinforcement.

Electrical Insulation Grade

This vulcanized fibre (sometimes called fish paper in thin sections) is made from high grade paper which is unusually free

(text continues on p 135)

STANDARD GRADES—FORMS, CHARACTERISTICS AND APPLICATIONS

NEMA Grades	Available Forms[a]	Resin	Thickness Range, in.	Finishes Available[b]	Colors	Type and Characteristics	Typical Applications
PAPER-BASE							
X	Sheet, Tube (r, m)	Phenolic	0.010-2.0	Semi-gloss	Natural, black	**Mechanical uses requiring strength and rigidity.** Electrical properties secondary; laminate should be used under dry conditions	Structural parts for radio, aircraft and electrical equipment and switchgear. Terminal boards or panels, insulating washers, bushings, coil forms, brush-holder bushings
P	Sheet	Phenolic	0.010-¼	Semi-gloss, dull	Natural, black, chocolate	**Hot punching grade.** Heated to 200-250 F. thicknesses up to ⅛ in. can be punched. Sheets up to 1/16 in. can be punched cold. More flexible and not as strong as X. Falls between X and XX in moisture resistance and electrical properties	Insulating washers, terminal boards, plug and socket bases, switch bases and panels for subassemblies
PC	Sheet	Phenolic	1/32-¼	Semi-gloss, dull	—	**Cold punching grade.** More flexibility and higher cold flow, but lower flexural strength than Grade P. Sheets up to ⅛ in. can be punched and sheets up to 3/32 in. can be sheared in 1½ in. wide strips both lengthwise and crosswise at room temperature	Motor and generator terminal boards, insulating washers, terminal strips, switch bases and panels, staked terminal boards and strips
XX	Sheet, rod, tube (r, m)	Phenolic	0.010-2.0	Semi-gloss, polished	Natural, black	**General purpose electrical grade.** Good machinability	Panels for switchboards and instruments, switch and circuit breaker arms, terminal blocks for motors and transformers, coil forms for radio and television, brush holder bushings, bobbin heads and spools
XXP	Sheet	Phenolic	0.015-¼	Semi-gloss, dull	Natural, black	**Better electrical and moisture resistance than XX.** More suitable for hot punching	Condenser stator brackets, wave change switch rotors and stators, plug and socket bases, terminal boards and subpanels, insulating washers
XXX	Sheet, tube (r, m)	Phenolic	0.015-2.0	Semi-gloss, polished	Natural, black	**Radio frequency and high humidity applications.** Minimum cold flow	Panels for radio and television equipment; jack spacers, radio coil forms, high voltage switchgear
XXXP	Sheet	Phenolic	0.015-¼	Semi-gloss, dull	Natural	**High insulation resistance and low dielectric loss under severe humidity conditions.** Better electrical properties than XXX and more suitable for hot punching. Falls between XXP and XX in punching characteristics	Condenser stator brackets, wave change switch rotors and stators, terminal boards and subpanels, coil support bases
ES-1	Sheet	Usually melamine	3/64-¼	Dull, polished	Black or gray surface, white core	**Engraving and decorative grade**	Engraved nameplates, signs
ES-2	Sheet	Usually phenolic	0.085-¼	Dull, polished	Black or gray surface, white sub-core, black core	**Similar in application to ES-1.** Phenolics usually used as binder to get toughness in thick sections	Engraved nameplates, signs
ES-3	Sheet	Phenolic	3/64-¼	Dull, polished	White or gray surface, black core	**Similar in application to ES-1**, but colors reversed	Engraved nameplates, signs
COTTON FABRIC-BASE							
C	Sheet, rod, tube (r)	Phenolic	1/32-10	Semi-gloss	Natural, black	**Mechanical applications requiring toughness and impact strength.** There may be several subgrades in this class adapted to specific end use	Gears and pinions, cams, pulleys, bobbin heads, chemical piping and fittings, bearings

STANDARD GRADES—continued

NEMA Grades	Available Forms[a]	Resin	Thickness Range, in.	Finishes Available[b]	Colors	Type and Characteristics	Typical Applications
CE	Sheet, rod, tube (m)	Phenolic	1/32-2.0	Semi-gloss, polished	Natural, black	**Electrical applications requiring greater toughness than XX, or mechanical applications requiring greater moisture resistance than C.** Not recommended for primary insulation in applications involving commercial power frequencies at voltages over 600	Switchboard panels, circuit breaker and switch arms, terminal blocks, electrode supports for plating tanks, bases for motors, bobbin heads (often in combination with XX)
L	Sheet, rod, tube (r, m)	Phenolic	0.010-2.0	Semi-gloss	Natural, black	**Mechanical uses where toughness requirements are lower than for C.** Suitable for fine machining applications, particularly in thicknesses under ½ in.	Small gears and pinions, parts requiring intricate machining, breaker arms, fairleads and knobs
LE	Sheet, rod, tube (r, m)	Phenolic	0.015-2.0	Semi-gloss, polished	Natural, black	**Electrical applications requiring greater toughness than that of XX.** Better machining properties and appearance than CE. Good moisture resistance. Not recommended for primary insulation in applications involving commercial power frequencies at voltages over 600	Terminal blocks and strips, panels, high humidity applications
MC	Sheet, rod	Melamine	1/16-2.5	Semi-gloss	Natural	**Good alkali and arc resistance.** Made from purified cotton fabric	Plating barrel applications, others requiring good resistance to caustics
ASBESTOS-BASE							
A (Paper)	Sheet, tube (r, m)	Phenolic	0.025-2.0	Semi-gloss	Natural or gray-black	**More resistant to flame and heat than cellulosic-reinforced grades.** Small dimensional changes when exposed to moisture. Not recommended for primary insulation in applications involving commercial power frequencies at voltages over 250	Mechanical parts in drying ovens, tenter rails
AA (Fabric)	Sheet, tube (r, m)	Phenolic	1/16-2.0	Semi-gloss	Natural	**More resistant to heat and stronger than A**	Rotor vanes, water pumping thrust washers, armature slot wedges, caustic resistant applications, electric appliance insulation
GLASS-BASE							
G-2	Sheet	Phenolic	1/32-2.0	Semi-gloss	Natural	**Electrical and heat resistant grade.** Good electrical properties under high humidity. Low dielectric loss. Good dimensional stability. Weakest of the glass-base grades. Made with staple fiber cloth	Class B insulation, other applications where good temperature resistance is required, but mechanical properties are not critical
G-3	Sheet, rod, tube (r)	Phenolic	0.010-2.0	Semi-gloss	Natural	**General purpose grade.** High impact and flexural strength; good electrical properties under dry conditions; good dielectric strength perpendicular to laminations; and good dimensional stability. Made with continuous filament glass cloth	Armature slot wedges, structural parts requiring good electrical properties, electrical equipment operating at relatively high temperatures
G-5	Sheet, rod, tube (r, m)	Melamine	0.010-3.5	Semi-gloss	Natural	**Highest mechanical strength and hardest laminate grade.** Good flame resistance; second only to silicone laminates in heat and arc resistance. Excellent electrical properties under dry conditions. Low insulation resistance under high humidities. Made with continuous filament cloth	Switchboard panels, arc barriers and circuit breaker parts, armature and slot wedges, structural parts, electrical applications requiring high strength and arc resistance, high temperature applications
G-6	Sheet	Silicone	1/16-2.0	Semi-gloss	Natural	**Class H insulation.** Dielectric loss and insulation resistance properties excellent under dry conditions. Good electrical properties under humid conditions. Excellent heat and arc resistance. Second only to G-5 in flame resistance. Good impact strength; other mechanical properties fair. Made with staple fiber cloth	Insulation applications where high temperature resistance, arc resistance and low losses are needed, such as Class H transformers

(continued on p 134)

STANDARD GRADES—continued

NEMA Grades	Available Forms[a]	Resin	Thickness Range, in.	Finishes Available[b]	Colors	Type and Characteristics	Typical Applications
G-7	Sheet	Silicone	0.010-2.0	Semi-gloss	Natural	**Class H insulation. Dielectric strength perpendicular to laminations is best of silicone grades.** Bond strength slightly lower than for G-6, but tensile and flexural strengths are higher. Made with continuous fiber cloth	Radio transmitter parts; Class H transformers; low loss, high frequency radio and radar insulators; motor slot wedges; slot liners; top sticks
G-10	Sheet, rod tube (r)	Epoxy	0.010-1.0	Semi-gloss	Natural	**Extremely high flexural, impact and bond strengths at room temperature. Good dielectric strength and loss properties under both dry and humid conditions.** Insulation resistance under high humidity is better than for G-6 or G-7	Printed circuits, other applications where high insulation resistance and dimensional stability are required
GPO-1	Sheet	Polyester	1/16-1.0	—	—	**General purpose grade for mechanical and electrical uses.** Uses random fiber mat reinforcement	Panel boards, slot wedges, spacers, coil blocking, layer insulation, core corner protectors, terminal plates, structural applications
NYLON-BASE							
N-1	Sheet, rod, tube (m)	Phenolic	0.010-1.0	Semi-gloss	Natural	**Excellent electrical properties under high humidity.** Good impact strength, but subject to flow or creep at temperatures higher than normal	High voltage applications: radio wave change switch stators and rotors, where low losses are critical; and electrical insulating parts that must be postformed
VULCANIZED FIBRE							
Commercial	Sheet, rod, tube	Regenerated cellulose	0.004-2.0	—	Red, black, gray	**General purpose grade.** High mechanical and dielectric strength. Good shock absorbing and wear resisting qualities. Excellent punching, forming and turning characteristics	Washers, terminal block covers, insulating plates and switch covers, arch supporters, bobbin and coil spool heads, arc barriers, shoe fibre, switch and appliance insulation, knee pads, golf club head plates, deep formed parts
Trunk	Sheet	Regenerated cellulose	0.010-3/16	—	Walnut, russet, chocolate, olive, mahogany, granite, white, black	**Better formability, greater smoothness, cleaner surfaces and better color than Commercial Grade,** but otherwise similar in properties	Trunks, cases, wastebaskets, mill boxes
Electrical insulation	Sheet, rod, tube	Regenerated cellulose	0.004-1/8 [c]	—	Gray	**Excellent dielectric strength.** High toughness and bending strength. Good abrasion and tear resistance. Excellent punching and forming characteristics	Armature slot insulation, armature end laminations, field coil insulation, metal box liners, washers, arc shields, formed slot wedges, gaskets, specialties
Bone	Sheet, rod, tube	Regenerated cellulose	1/32-1/2	—	Gray	**Maximum hardness and stiffness.** High mechanical strength and wear and abrasion resistance. Highest machinability	Gears, cams, fairleads, bushings, grommets, switch handles, terminal blocks, armature slot wedges threaded and tapped pieces, sugar tips

[a] For tubing: m=molded, r=rolled.

[b] Finishes refer to sheet. Round tubes and rods in grades G-3, -5, -6, -7, -10, and N-1 available with ground finish; all other grades available ground, buffed or varnished. Square and rectangular molded tubes in grade AA are available semi-gloss or ground; all other grades available semi-gloss, ground or varnished.

[c] Thin material of this grade is sometimes called fish paper.

from foreign matter that might impair dielectric efficiency. It is extremely tough, and has high dielectric strength and excellent bending qualities. Its hard surface resists abrasion, and it has excellent punching and forming qualities.

Special grades have been somewhat standardized by producers:

1. Track insulation fibre, designed to meet specifications of the American Association of Railroads for insulating rail joints. Its high density prevents flow or plastic deformation under load, and it is particularly adaptable to forming to rail contours.

2. Hermetic grades, featuring high purity and low concentrations of extractable elements. These grades have been developed specifically as insulation for electric motors in hermetically sealed refrigeration units where the insulation must withstand constant immersion in refrigerants.

General Purpose (Mechanical-Electrical) Grades

The general purpose classification includes relatively expensive grades which have good mechanical and electrical properties and can be used for either type of application. It also includes special purpose materials, such as asbestos-reinforced laminates which provide higher resistance to flame and heat than the cellulose-base materials. There are nine general purpose grades: one cotton-base phenolic laminate; two asbestos-base phenolic laminates; four glass cloth-base laminates—one a phenolic, one a melamine, one an epoxy and one a polyester; and two grades of vulcanized fibre.

Grade CE

This material is a medium weave, canvas-base phenolic laminate used for electrical applications requiring greater toughness than Grade XX provides, or for mechanical applications requiring greater moisture resistance than Grade C provides. It has better dielectric properties, but lower impact strength, than Grade C. It is tough and resilient, and has good wear qualities and high fatigue strength. It is not recommended for primary insulation. Grade CE molded tubing has better threading and machining characteristics than Grade C rolled tubing.

Special grades with medium weave canvas reinforcements are available for pump valve applications. They have good resistance to moisture, solvents and acids. So-called steaming bobbin stock is made with a fine weave, purified canvas base for applications requiring retention of smooth edges and reasonable impact strength. Other special grades have particularly good machining characteristics and low loss characteristics at 60 cycles.

Grade A

This asbestos paper-base phenolic laminate is more flame resistant and somewhat more resistant to heat than cellulose-reinforced grades because of its high inorganic content. It retains strength relatively well after exposure at fairly high temperatures; for best results at high temperatures, the laminate should be heat treated after rough machining and before final machining. Machining is somewhat difficult. Impact strength is intermediate between those of paper-base and cloth-base laminates. In electrical uses, Grade A is suitable for low voltage applications only.

Grade AA

Grade AA is an asbestos cloth-base phenolic laminate that is stronger, tougher and more heat resistant than Grade A. It is made with AA grade asbestos fabric, containing a minimum of 90% asbestos by weight.

Special grades using felted or matted asbestos reinforcements are available. These grades have higher tensile and flexural strengths than Grade AA and the best machining and punching characteristics of the asbestos-base grades.

Grade G-3

This continuous filament, glass cloth-base phenolic laminate combines good electrical and mechanical properties with excellent heat resistance. It has good electrical properties under dry conditions, good dielectric strength perpendicular to laminations, and good dimensional stability.

Grade G-5

This grade is a continuous filament, glass cloth-base melamine laminate having the highest mechanical strength of all NEMA grades. It also has excellent electrical properties under dry conditions, but its insulation resistance under high humidity conditions is low. It has good flame resistance, is second only to Grade G-7 in arc resistance, and has good dimensional stability. Punching and machining are difficult, however.

Grade G-10

This continuous filament, glass cloth-base epoxy laminate has the highest insulation resistance and dielectric strength of the glass-base grades, an extremely low dissipation factor, and the lowest water absorption of all NEMA grades. It also has exceptional mechanical properties and good dimensional stability. It has the highest bond strength of the NEMA grades.

Special grades are available with better heat resistance and better strength retention at elevated temperatures, though bond strength and water absorption characteristics suffer somewhat. Other special grades are available with better flame resistance.

Grade GPO-1

This is a random fiber, glass mat-base polyester laminate de-

signed to serve as a moderate cost, general purpose material. It has good mechanical and electrical properties, and good cold punching characteristics.

Special grades are available with tensile and flexural strength values in the 40,000 psi range, but with somewhat lower electrical characteristics. Other special grades include: 1) self-extinguishing grades, 2) low cost grades having fair mechanical and electrical properties, and 3) grades which meet Underwriters' specifications for sole support of current carrying parts at temperatures up to about 300 F.

Commercial and trunk grades

These vulcanized fibres are two general purpose grades with high mechanical and electrical properties. Both grades have good dielectric strength; good impact strength; good resistance to organic solvents, oils and gasoline; and good surface finish. The two are similar in end properties, but Trunk Grade is easier to form, has smoother and cleaner surfaces, and is available in more colors. It is intended for use in trunks, baskets and carrying cases.

Special grades have become relatively standardized by several producers:

1. Flexible fibre, a treated material providing softness and resilience, yet retaining toughness and abrasion resistance.

2. Abrasive fibre, tough and resilient with high tear strength, yet rigid enough to provide a firm flexible backing for abrasive disks and belts.

3. White fibre, an attractive, tough grade resistant to oils, dry cleaning fluids and most solvents. It can be printed or lithographed.

4. Bobbin fibre, tough, light and nonsplintering, with a glass-smooth machined finish. It has high impact strength and can be punched. This grade is used in textile bobbins and spool heads.

5. Guard fibre, a lightweight, high impact strength material used for athletic and industrial protective guards.

Combination Laminates

Plastics laminates combined with lamina of other materials sometimes provide useful combinations of properties. These other materials may be used as facings for plastics laminates or they may be sandwiched between layers of plastics laminates.

Copper faced laminates

Probably the most widely used combination laminates are the copper faced laminates used for printed circuits (see M&M, July '55, p 94). Laminates are available with electrolytic or rolled copper foil in thicknesses of 0.00135 in. (1 oz), 0.0027 in. (2 oz) or greater bonded to either one or both sides. Table 3 shows foil circuit overloads for 1 and 2 oz foil circuits. Selection of the grade and quality of the base laminate depends on requirements such as low loss insulation, mechanical strength, moisture resistance, heat resistance and ease of fabrication.

Grade XXXP laminates are recommended for the usual printed circuit applications, since they have excellent insulation resistance, good punching qualities and low dielectric losses even under high humidity conditions. Other laminates used are Grades XP, XX, XXP, LE, G-3, G-5, G-10, CE, PC, N-1, a modified G-10 and other modifications of these grades, depending on specific design requirements.

A recently developed paper-base epoxy laminate is said to combine good mechanical strength, low water absorption and good thermal resistance with high dielectric properties. Tensile strength is in the range of 18,000 psi, modulus of elasticity in tension is about 1.15×10^6 psi and flexural strength is around 25,000 psi. Dielectric strength (step by step) is about 820 v per mil. Dissipation factor is about 0.0096 for dry 1/8 in. thickness at 60 cps, and rises only to 0.0633 after 24 hr water immersion.

Bond strength for most commercial copper-faced laminates is between 4 and 8 lb per in. width for 1-oz foil and slightly higher for 2-oz foil. It is important to remember that the surface resistivity of an etched circuit depends on the adhesive used to bond the laminate to the copper, since the etchant removes the copper but not the adhesive. Surface resistivity with conventional adhesives is about 1.4×10^6 megohms per square (cond C-96/35/90).

Copper-faced laminates made by a relatively new bonding process have approximately double the bond strength of previous laminates, but at a sacrifice in surface resistivity. The process, developed by Houghton Laboratories, Inc., creates an adherent cupric oxide film on the copper, then bonds the copper to the laminate with a modified rubber-phenolic adhesive. With Grade XXXP laminates, bond strengths are on the order of 12-17 lb per in. width for electrolytic copper and 8-10 lb per in. for rolled copper foil. Dip solder resistance varies from 10 to over 30 sec at 500 F. Surface resistivity values range from 620,000 to 1.25×10^6 megohms per

TABLE 3—FOIL CIRCUIT OVERLOAD RATINGS

Width, in.	1-oz Foil (0.00135 in.)		2-oz Foil (0.0027 in.)	
	Amperes	Ohms[a]	Amperes	Ohms[a]
1/4	23	0.002	35	0.0009
1/8	15	0.004	20	0.0018
1/16	10	0.008	15	0.0035
1/32	5	0.016	8	0.007
1/64	3	0.032	5	0.015

[a]Ohms per in. for 100% IACS copper.

square (cond C-96/35/90). This deficient surface resistivity may be upgraded by development work currently under way, but to date it is a limitation.

One significant improvement in printed circuit laminates is the development of special grades that can be cold punched. Use of cold punching eliminates distortions due to the heat involved in hot punching, and thus provides more accurate circuits.

Copper faced laminates that can be postformed are also available for use in producing semicylindrical or shaped circuits. Such laminates are usually supplied with foil on both surfaces to prevent warpage. Design limitations of these postformable laminates depend on the type of base laminate and the location of the copper circuit on the laminate. Table 4 shows the effect of the position of the copper circuit on the laminate on the minimum bend radii for various laminate thicknesses.

Laminates with rubber

Combination laminates utilizing various types of rubber can be obtained. These combination laminates are particularly well suited for applications requiring resilience, shock absorption or metal sealing characteristics. They can be obtained with rubber on one or both sides, with rubber sandwiched between laminates, or in alternating layers of rubber and laminate. Though rubber can be laminated to almost any grade of material on special order, most suppliers have certain stock grades available. For example, one supplier stocks rubber combined with Grades XP and C; another stocks rubber combined with Grades P, XXP, C, CE and L. Not only the thermosetting plastics laminates, but also vulcanized fibre can be obtained with rubber laminations.

There are several types of rubber from which to select a grade to meet specific design requirements. Red Buna S, sometimes called gasket rubber, should be used for metal sealing applica-

How Printed Circuits Are Made

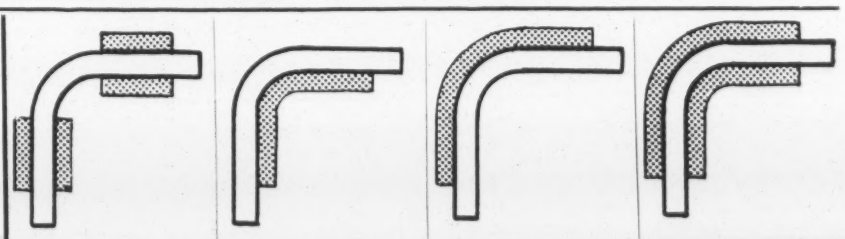
Standard printed circuits are produced by etching. A resist is first applied to the copper by either photoengraving or silk screen printing. The unprotected areas of copper are then etched by immersion in etchants, such as 40° Baumé ferric chloride solution, leaving the protected copper circuit on the laminate.

Where copper circuits are to be protected by an electroplate such as gold, silver, nickel or rhodium, the copper is made the cathode in a standard electroplating bath. The plating can be done either before or after the circuit is etched. When plating before etching, a resist is applied to the copper to prevent plating the noncircuit area. Thus the circuit area is left bare to act cathodically in the bath. After plating, the resist is removed and the plated area serves as the resist while the copper is etched away. The result is a copper circuit protected by an overlay of plated metal.

In flush circuits the copper conductors are embedded in the laminates. Most flush circuits used today are made by first producing a standard etched circuit, then pressing it into a laminate, such as a standard soft Grade XXXP. Because of the number of steps in the process, flush circuits cost roughly five to seven times as much as etched circuits. Also: intricacy of circuits is limited, only a few circuits can be produced on one laminate, and the types of base laminates that can be used are limited. A completely flush circuit face is difficult to obtain. Circuits usually extend as much as 0.003 to 0.004 in. above the face of the laminate.

A new method of producing flush circuits promises to overcome most of these limitations. Cost of the new type of flush circuit is said to be only about twice that of a standard etched circuit. In addition, intricacy obtainable is said to be equivalent to that obtainable in etched circuits, any base laminate can be used, and tolerances on flatness of circuit faces can be held to within 0.0001 in.

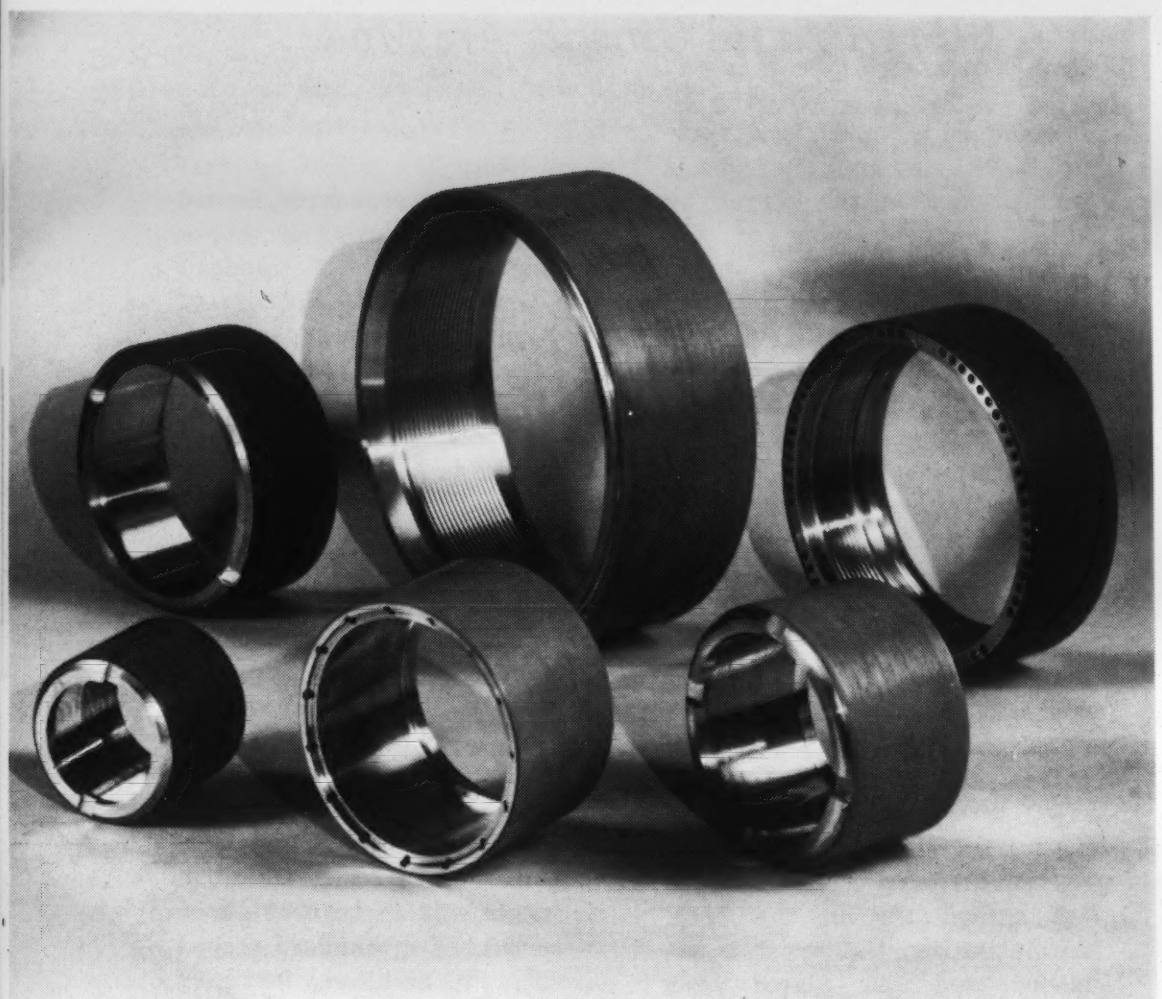
TABLE 4—SUGGESTED BENDING LIMITATIONS FOR POSTFORMING PRINTED CIRCUITS[a]



Sheet Thickness, in.	NO COPPER ON EITHER SURFACE OF BEND Minimum Radius, in.	COPPER ON INSIDE OF BEND ONLY Minimum Radius, in.	COPPER ON OUTSIDE OF BEND ONLY Minimum Radius, in.	COPPER ON BOTH SURFACES OF BEND Minimum Radius, in.
1/32	1/32	—	—	—
3/64	—	5/16	9/16	—
1/16	3/32	3/8	11/16	1 5/8
3/32	3/16	5/8	1 1/2	—
1/8	3/8	1	2	—
3/16	5/8	—	—	—
1/4	1	—	—	—
5/16	1 3/4	—	—	—
3/8	2 1/2	—	—	—

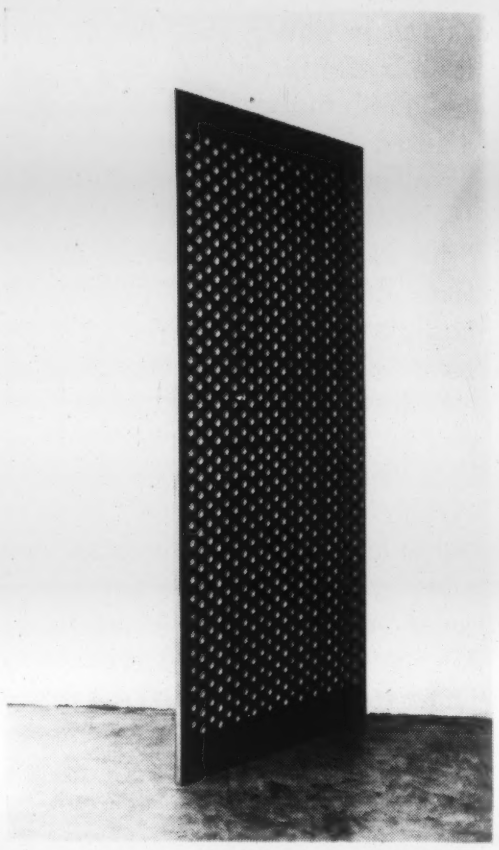
[a]Values are given for a postformable Grade N-1 laminate. Radii are measured on inside of bend and apply to bends made lengthwise, crosswise or diagonally across the sheet.
Source: Formica Corp.

Plastics laminates are combined with other materials in . . .



Synthane Corp.

Piston heads *for aircraft landing struts. Combination of cloth-base laminate and aluminum provides high strength-weight ratio and resistance to hydraulic fluids. It also prevents metal-to-metal contact that might result in seizing during aircraft landings. Sizes shown range from 3-in. piston for fighter planes to 10-in. piston for transports.*



Farley & Loetscher Mfg. Co.

Deck of a drier car *used for oven-drying clay pipes. Material consists of Grade X laminate facing on both sides of ¾-in. plywood. Decks have operated in 160 F, 70% R.H. ovens for over three years without deterioration. They are simpler to install and provide longer life than maple slabs previously used.*

tions. Chloride and sulfate-free Buna S is a specially processed synthetic rubber for applications requiring this type of chemical purity. Buna N, in either black or gray, is a nitrile type synthetic rubber with good oil resistance as well as freedom from chlorides and sulfates. Neoprene, in either black or brown, is a chlorinated synthetic rubber with good oil and heat resistance.

Other combinations

Electrical Insulation Grade vulcanized fibre bonded to a variety of reinforced laminates is suitable for applications such as arc barriers. Such combinations provide laminates with high arc resistance and a wide range of toughness, impact strength, rigidity and appearance, depending on the grade and thickness of the reinforced laminate and the thickness of the fibre.

Laminates bonded to other metals besides copper are available to meet various design requirements. Metals that can be bonded include steel, aluminum, nickel and bronze. These combinations provide materials with the surface characteristics of the metals and the light weight and dielectric properties of high pressure laminates. Such combinations can be used to reduce weight, improve corrosion and chemical resistance, improve fabrication characteristics, and add stiffness to soft sealing metals.

Laminates consisting of more than one grade of reinforced laminate can also be obtained to provide desired properties in specific areas of a part. For instance, bobbin heads for spools in the textile industry are often made of a combination of Grades C and XX. The outside half of the spool head is made from Grade C to reduce breakage due to rough handling, and the inside is made from Grade XX to provide a smooth take-off surface for fine filament yarns.

Asbestos paper laminated to vulcanized fibre is used for special applications, such as arc barriers and deflectors in high voltage arc interrupting devices. This material combines the high flame resistance of asbestos with the good arc resistance of fibre.

Fabricating Characteristics

Forming

Vulcanized fibre—Moisture is to vulcanized fibre what heat is to metals. That is, water softens or plasticizes the fibre to the extent that it can be formed under relatively low pressures, usually between 200 and 500 psi. In addition to forming in matched die presses, vulcanized fibre can be formed in standard sheet metal angle brakes and in punch presses if the design is simple and only a little moisture is required.

The amount of soaking in hot water (260-210 F) and the amount of pressure needed for forming depends on the thickness of the fibre and the depth of draw or severity of the shape. Most formed fibre products are made from material between 1/32 and 3/16 in. thick. This thickness range permits good drawing qualities, yet gives ample strength and rigidity. Where sharp contours and deep draws are to be made the material should be 1/16 to 3/32 in. thick. Pressure plates are necessary for severe draws to prevent wrinkling of the fibre.

In general, wet fibre can be stretched up to about 25% and compressed about 50%. In other words, a 3-in. circular disk can be drawn to a cup 1½ in. dia and about 1⅛ in. deep. For cubical shapes, depth of draw should be about one-third the length of the face diagonal. Depth of spherical draws should be approximately one-half the average diameter of the opening.

Dry vulcanized fibre can be formed to a moderate degree if heated to about 350 F. Though relatively simple shapes can be produced, the extent to which dry fibre can be drawn or bent is considerably less than that possible with wet fibre. Dry vulcanized fibre can also be swaged by forcing it into a die cavity under high pressure, usually with heat.

Reinforced laminates — Postformable grades of reinforced laminates utilize an aniline type resin binder or a plasticized phenolic binder to provide a degree of thermoplastic behavior. These laminates can be postformed into relatively complex shapes by flash heating to a high temperature and shaping quickly in molds or forms. Parts must be held in the desired shape until cooled to a temperature at which they permanently retain their shape.

Temperatures, times and pressures vary with the laminate grade, thickness of material and design shape. Temperatures generally range between 350 and 480 F, heating times are usually a few seconds to a few minutes at most, and pressures range from a few pounds for simple bending to several hundred pounds for drawing thick sheets. Dies can be made of wood, metal or plastics.

The available postforming laminates are special grades of X, XX, C and N-1. In general, properties are similar to those of corresponding standard grades and they are relatively unaffected by the postforming process, though mechanical strength is usually increased slightly. Cloth-base laminates are generally more formable than paper-base grades and provide postformed shapes of better quality. Current paper-base postforming grades make use of crepe paper, providing substantial improvements in formability.

Although the following formability values should not be used for design, they do indicate general design limits for postforming. Minimum radii are measured on the inside of bends, and apply to bends made lengthwise and crosswise. Smaller radii can be achieved with cloth-base laminates by orienting the sheet so that bends are made diagonally to the warp and fill directions.

Thickness, in.	Min Bend Radius, in.
1/32	1/32
1/16	3/32
3/32	3/16
1/8	5/16
3/16	9/16
1/4	1
5/16	1-3/4
3/8	2-1/2

Postforming grade laminates can be drawn to moderate depths. Both paper and cloth-base laminates in 1/16 in. thickness can be drawn to a depth of about 1¼ in. for a 3 in. dia spherical cup.

Specifications applying to postforming fabric-base laminates can be found in: 1) National Electrical Manufacturers' Assn. *Standards for Industrial Laminated Thermosetting Products,* Part 9; 2) Society of Automotive Engineers *Specification AMS 3605C;* and 3) Military Specification *MIL-P-8655A. Laminated Thermosetting Sheets, Cotton-Fabric-Base, Post-Forming.*

Other fabricating processes

Machining — Vulcanized fibre and reinforced laminates can usually be fabricated with standard woodworking or metalworking tools and machinery, though some modifications are desirable. For example, higher cutting speeds are usually practical because of the free-machining characteristics of many laminates. Also, in all machining operations tools must be kept extremely sharp.

Glass-base laminates require some special precautions. Glass-silicone laminates (Grades G-6 and G-7) generally have relatively low bond strengths, and fabrication procedures should be modified accordingly. With any glass-base grade, moreover, cutting edges tend to wear more rapidly than with cellulose base laminates, and glass dust produced in fabrication can cause wear on parts not in direct contact with the material. Adequate exhaust facilities should be provided to prevent irritation to the operator.

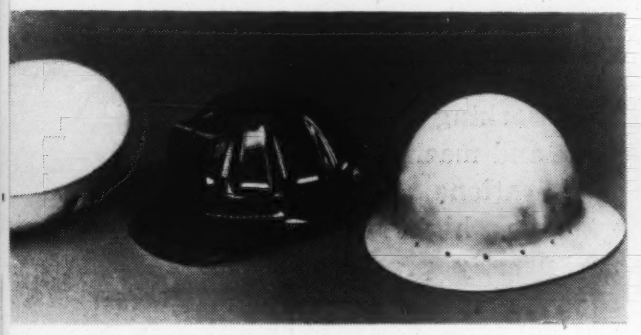
Laminates can be machined on high speed screw machines. They can also be milled, drilled, fly-cut, turned, threaded and tapped, swaged and flared, and shaved.

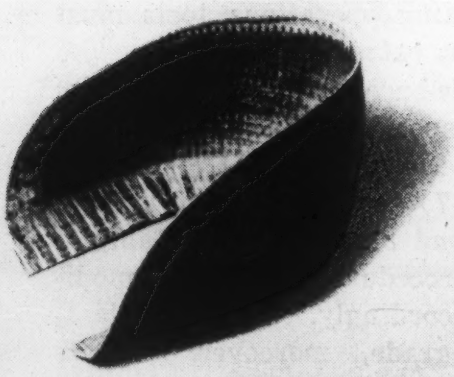
Cutting — Laminates can be sheared on metal squaring shears of the guillotine type. Punching and cotton fabric-base grades can be sheared cold in thicknesses up to about ⅛ in., whereas fibre can

Laminates can be shaped by . . .

Panelyte Div., St. Regis Paper Co.

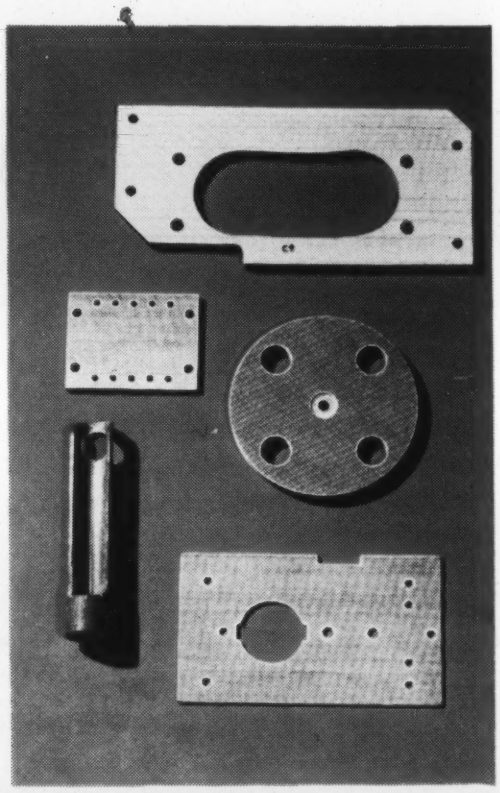
Molding or postforming. *Parts in foreground are molded; parts in background are postformed. Below is a backing plate for a Minneapolis Honeywell thermostat which uses canvas-base postforming stock.*





National Vulcanized Fibre Co.

Forming and drawing *wet vulcanized fibre to make such things as safety hats and safety shoe heels.*



Panelyte Div., St. Regis Paper Co.

Machining *sheet, rod or tubing to make parts like those shown here.*

be sheared in thicknesses up to about 3/8 in. The harder stocks should be heated to 200-280 F before shearing.

Slitting can be done on standard rotary blade slitters, holding closer tolerances than are possible with shearing. Fibre can be slit in thicknesses up to 7/32 in., and reinforced laminates can be slit in thicknesses up to about 5/32 in., depending on the grade. Again, the harder grades should be heated to 200-280 F.

Laminates can be sawed with standard band saws or standard floor or bench circular saws. Band saws should be file-hard carbon steel or hardened steel with soft backs. Laminates up to 10 in. thick can be band sawed, using proper techniques. Circular saws should be hollow-ground high speed steel or carbide tipped. Where tolerances are critical laminates can be circular sawed in thicknesses up to about 1 in.

Abrasive cut-off machines can be used on laminates up to about 2 in. thick. Producers recommend this method for cutting glass and asbestos-base reinforced laminates.

Punching—Punchable laminates can be cold punched in maximum thicknesses ranging from 1/32 to 1/8 in., and hot punched in maximum thicknesses ranging from 3/32 to 1/8 in. Fibre can be punched in thicknesses up to about 1/4 in. Progressive dies provide high speed production, but compound dies are more satisfactory for intricate pieces. Extremely close tolerances are difficult to hold on hot punched laminates because of contraction on cooling.

Finishing — Laminates can be finished by burring, tumbling, cleaning and buffing. All or some of these operations are generally necessary to finish a fabricated part. Finished surfaces are suitable for painting, lacquering, varnishing, enameling or coating with any synthetic finish. They can also be decorated by silk screen printing.

References

Albert, G. A., "Vulcanized Fibre: New Look at an Old Plastic," MATERIALS & METHODS, Sept '54, p 110.

Dietz, A. G. H., *Engineering Laminates*, John Wiley & Sons, Inc., New York, 1949.

Acknowledgment

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Continental-Diamond Fibre Div. of Budd Co., Inc.
Farley & Loetscher Mfg. Co., Plastics Div.
Formica Corp., Subsidiary of American Cyanamid Co.
General Electric Co., Laminated and Insulating Products Dept.
Glastic Corp.
Hays Mfg. Co., Reinforced Plastics Div.
Houghton Laboratories, Inc.
Mica Insulator Co.
Micarta Div., Westinghouse Electric Corp.
National Electrical Manufacturers' Assn.
National Vulcanized Fibre Co.
Northern Plastics Corp.
St. Regis Paper Co., Panelyte Div.
Richardson Co.
Spaulding Fibre Co., Inc.
Synthane Corp.
Taylor Fibre Co.

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FILE FACTS

Wrought Nickel and Nickel Alloys — Materials Data Sheet

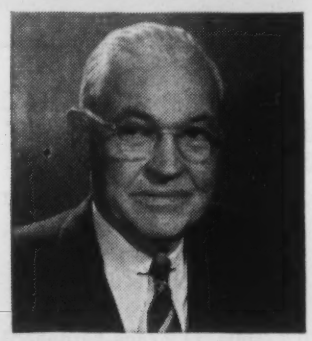
Type	"A" Nickel	Low Carbon Nickel	Duranickel
NOMINAL COMPOSITION, % by weight	Ni 99.45, C 0.06, Mn 0.25, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 99.55, C 0.01, Mn 0.20, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 93.90, C 0.15, Mn 0.25, Fe 0.15, S 0.005, Si 0.55, Cu 0.05, Al 4.05, Ti 0.45
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.321	0.321	0.298
Melting Range, F	2615–2635	2615–2635	2550–2620
Thermal Conductivity (80–212 F) Btu/hr/sq ft/ft/°F	36	36	10.7 (soft), 11.2 (age-hardened)
Coef of Ther Exp (80–212 F), per °F	7.4×10^{-6}	7.4×10^{-6}	7.2×10^{-6}
Specific Heat (80–212 F), Btu/lb/°F	0.130	0.130	0.104
Electrical Resistivity (32 F), microhm-cm	9.5	9.5	46.5 (soft)
Magnetic Transformation Temp, F	680	680	120 (soft)
Magnetic Properties	Magnetic	Magnetic	Slightly magnetic
MECHANICAL PROPERTIES[a]			
Modulus of Elasticity in Tension, psi	30×10^6	30×10^6	30×10^6
Tensile Strength, 1000 psi			
Annealed	55–75	50–60	90–120
Annealed, Age Hardened	—	—	160–190
Spring	90–130	—	155–190
Spring, Age Hardened	—	—	180–230
Yield Strength, 1000 psi			
Annealed	15–30	12–25	35–60
Annealed, Age Hardened	—	—	—
Spring	70–115	—	—
Spring, Age Hardened	—	—	—
Elongation in 2 in., %			
Annealed	55–40	60–40	50–130
Annealed, Age Hardened	—	—	25–10
Spring	15–2	—	10–2
Spring, Age Hardened	—	—	15–5
Rockwell Hardness			
Annealed	64B (max)	55B (max)	90B (max)
Annealed, Age Hardened	—	—	30–40C
Spring	95B (min)	—	30–40C
Spring, Age Hardened	—	—	36–46C
Fatigue Strength (endurance limit at 10^8 cycles), 1000 psi			
Hot Rolled	33	33	51
Hot Rolled, Age Hardened	—	—	52.5
Cold Drawn	50	50	51
Cold Drawn, Age Hardened	—	—	61
THERMAL TREATMENTS			
Annealing Temperature, F	1500 (2–5 min)	1500 (3–6 min)	1600 (2–5 min)
Aging Temperature, F	—	—	1100 (8–16 hr)
FABRICATING PROPERTIES			
Hot Working Temp Range, F			
Heavy Forging, Drop Forging	1600–2300	1400–2300	1900–2300
Light Forging	1200–1600	1200–1600	1600–1900
Joining Methods	Metallic arc, inert gas metal arc, oxyacetylene, resistance welding; silver and copper brazing; soft soldering		Metallic arc, inert gas metal arc, resistance welding; silver brazing; soft soldering
AVAILABLE FORMS	Sheet; strip; rods, bars and shapes; tube; plate		
USES	Generally used in process equipment for resistance to corrosion and high temperatures. Also used in electronic equipment for vacuum tube parts, leads and springs	Production and handling of molten caustic soda and other molten salts. Spun or coined parts. Long time service at 700–1200 F	Parts requiring corrosion resistance and strength at elevated temperatures, such as springs, dies for extruding plastics, fasteners, vacuum tube components

For more information, Circle No. 572

(continued on p 145)

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



Technical-ities
By John S. Davey

Tighten bolts to yield strength?

Actually, it is safer to "overtighten" than to undertighten. The following explains why.

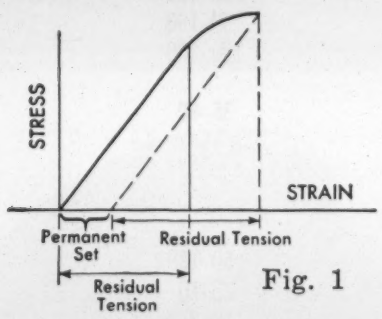


Fig. 1

Up to yield point, the strain in a bolt is proportional to stress. *Beyond* the elastic limit, the bolt goes into its "plastic range". Some permanent stretch takes place. (Fig. 1). Yet while the bolt will not return to original length, note that *residual tension* is fully maintained. And remember, it's *this* force that keeps a bolt tight, determines joint strength.

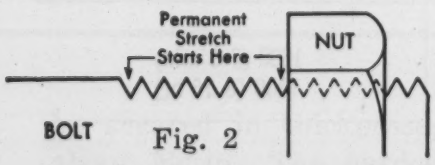
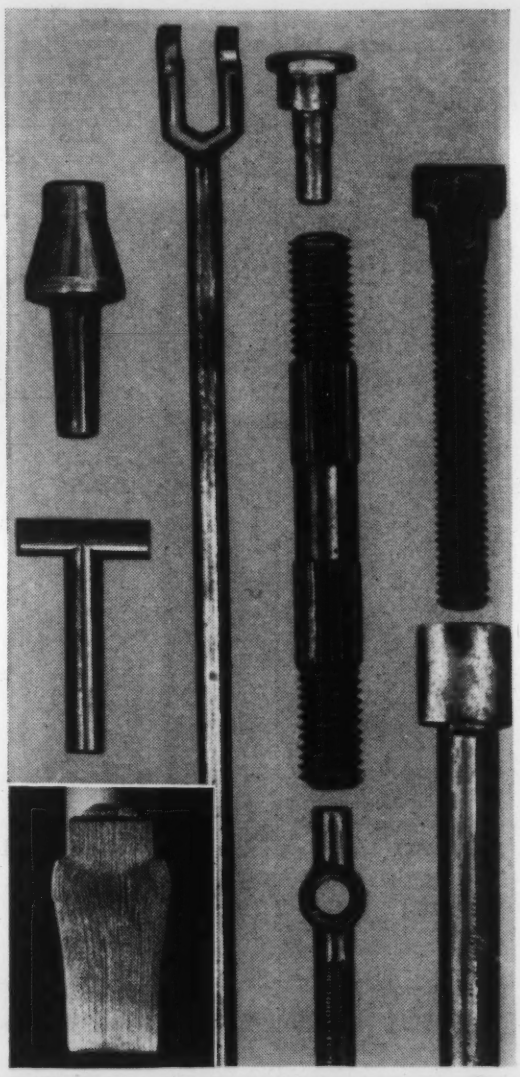


Fig. 2

The permanent set starts at section with highest unit stress —which is at the unengaged threads (Fig. 2). Ultimately, this throws thread pitch off and nut locks, subjecting bolt to torsion (rather than further tightening). This force disappears with wrench-removal. Thus, a bolt can even be torqued well into its plastic range if it won't be reused or need adjustment.

Cold facts on cold headed fasteners



RB&W cold heading machines have forced metal to flow into this typical variety of shaped pieces—just a handful of thousands of different cold headed shapes produced by RB&W to specification. The upset can be at any point, and the shape need not be symmetrical. The continuous, symmetrical flow lines (inset) make metal stronger.

NO ATTEMPT to simplify, improve or economize on fastening is complete without a good look at your screw machine parts, forgings, and certain assemblies that can be reduced to one piece.

You would be surprised at what an expert can produce on cold headers with complete uniformity. Cold heading produces in one piece parts that would otherwise be two or more.

BETTER FLOW LINES

Just as it does with standard fasteners, cold heading makes possible a higher quality, stronger product at high speed and low cost. Properly done, the operation upsets metal along its own axis in continuous flow lines without folds. Stress patterns are better. Fasteners and parts gain greater shear, impact and fatigue strength.

Long a specialist in cold headed fasteners, RB&W offers its experience to designers and production men who want to know whether cold heading is feasible for specific mechanical shapes. If it proves to be so, RB&W facilities can handle your volume needs. Contact Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Spin-Lock® Screws solve assembly problem

The designer specified countersunk-head screws to be used in a particular casting. The production man had to stake these in to anchor them. But this meant extra operation, made screw removal damaging and difficult.

The answer was found in Spin-Lock screws. These have hardened "ratchet-action" teeth that bite in when tightened, take 20% more torque to loosen than to tighten, can be reused. Send for Bulletin.

Spin-Lock "tooth" about to bite in. Head meets seat when fully tightened.

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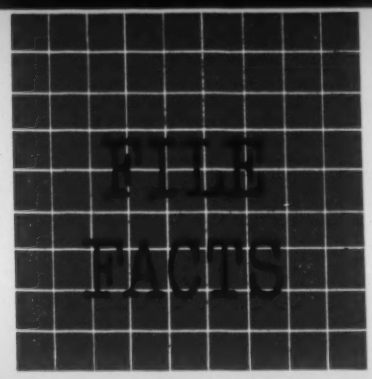

Wrought Nickel and Nickel Alloys (continued)

Type	Monel	"K" Monel	Inconel	Inconel "X"
NOMINAL COMPOSITION, % by weight	Ni 66.00, C 0.12, Mn 0.90, Fe 1.35, S 0.005, Si 0.15, Cu 31.50	Ni 65.30, C 0.15, Mn 0.60, Fe 1.00, S 0.005, Si 0.15, Cu 29.50, Al 2.80, Ti 0.50	Ni 76.40, C 0.04, Mn 0.20, Fe 7.20, S 0.007, Si 0.20, Cu 0.10, Cr 15.85	Ni 72.80, C 0.04, Mn 0.70, Fe 6.75, S 0.007, Si 0.30, Cu 0.05, Cr 15.15, Al 0.80, Ti 2.55, Cb + Ta 0.85
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.319	0.306	0.304	0.298
Melting Range, F	2370–2460	2400–2460	2540–2600	2540–2600
Ther Cond (80–212 F), Btu/hr/sq ft/ft/°F	15	10.8	8.7	8.7
Coef of Ther Exp (77–212 F), per °F	7.8×10^{-6}	7.8×10^{-6}	6.4×10^{-6}	9×10^{-6}
Specific Heat (70–750 F), Btu/lb/°F	0.127	0.127	0.109	0.10–0.11
Elec Res (68 F), microhm-cm	48.2	58.3	98.1	124.6 (122 F)
Magnetic Properties	Slightly magnetic	Nonmagnetic to −150 F	Nonmagnetic	Nonmagnetic
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	26×10^6	26×10^6	31×10^6	31×10^6
Tensile Strength, 1000 psi				
Annealed	70–85	90–105	80–100	110–130
Annealed, Age Hardened	—	130–170	—	155–180
Spring	100–140	145–165	145–170	200–225
Spring, Age Hardened	—	170–200	—	250–285
Yield Strength (0.2% offset), 1000 psi				
Annealed	25–45	40–65	30–45	45–65
Annealed, Age Hardened	—	90–120	—	100–125
Spring	90–130	130–160	120–160	230–240
Spring, Age Hardened	—	130–180	—	260–290
Elongation in 2 in., %				
Annealed	50–35	45–25	55–35	40–55
Annealed, Age Hardened	—	25–15	—	30–20
Spring	15–2	8–3	10–2	1.6 (approx)
Spring, Age Hardened	—	10–5	—	1
Rockwell Hardness				
Annealed	68B (max)	85B (max)	84B (max)	95B (max)
Annealed, Age Hardened	—	24–33C	—	30–37C
Spring	98B (min)	25–32C	30C (min)	—
Spring, Age Hardened	—	34–40C	—	—
THERMAL TREATMENTS				
Annealing Temperature, F	1600–1800 (open), 1400–1500 (box)	1400–1800 (1–5 min)	1600–1800	1900–2000 (15–30 min)
Solution Temperature, F	—	—	—	2100 (2-4 hr) a.c.
Aging Temperature	—	1100 (8–16 hr) f.c.	—	1550 (24 hr) a.c. 1300 (20 hr) a.c.
FABRICATING PROPERTIES				
Hot Working Temp Range (hot forging, drop forging), F	1700–2150	1900–2150	1700–2300	1800–2200
Cutting speed, ft/min[b]	125–225	100–200	100–175	—
Joining Methods	Metallic arc, inert gas metal arc, oxyacetylene, resistance welding; silver and copper brazing; soft soldering		Metal arc, inert gas metal arc, resistance welding; silver brazing	
AVAILABLE FORMS	Sheet; strip; rods, bars and shapes; tube; plate			Sheet; rods, bars and shapes
USES	General purpose alloy with combination of good strength, ductility and corrosion resistance. Condenser and heat exchanger tubes; pickling baskets, hooks and rods; pump shafts; valve stems; springs and fasteners	Greater strength and hardness than monel with same corrosion resistance and strength comparable with that of mild steel. Pump shafts and liners, valve seats and stems, electrical contact arms, springs and fasteners	Food processing equipment such as cookers, kettles, steamers and storage tanks. Other process equipment requiring similar combination of strength, corrosion resistance and good elevated temperature properties	High strength, high temperature alloy (can operate extended periods at 1000 F) for application in steam turbines, jet engines, heat treating equipment, etc. Also furnace muffles, springs, turbine blades, bellows and fasteners

[a]Properties vary with form and condition. Values listed are for sheet and strip unless specified otherwise.
[b]Surface speed with single point cemented carbide tools.

Courtesy of International Nickel Co., Inc.

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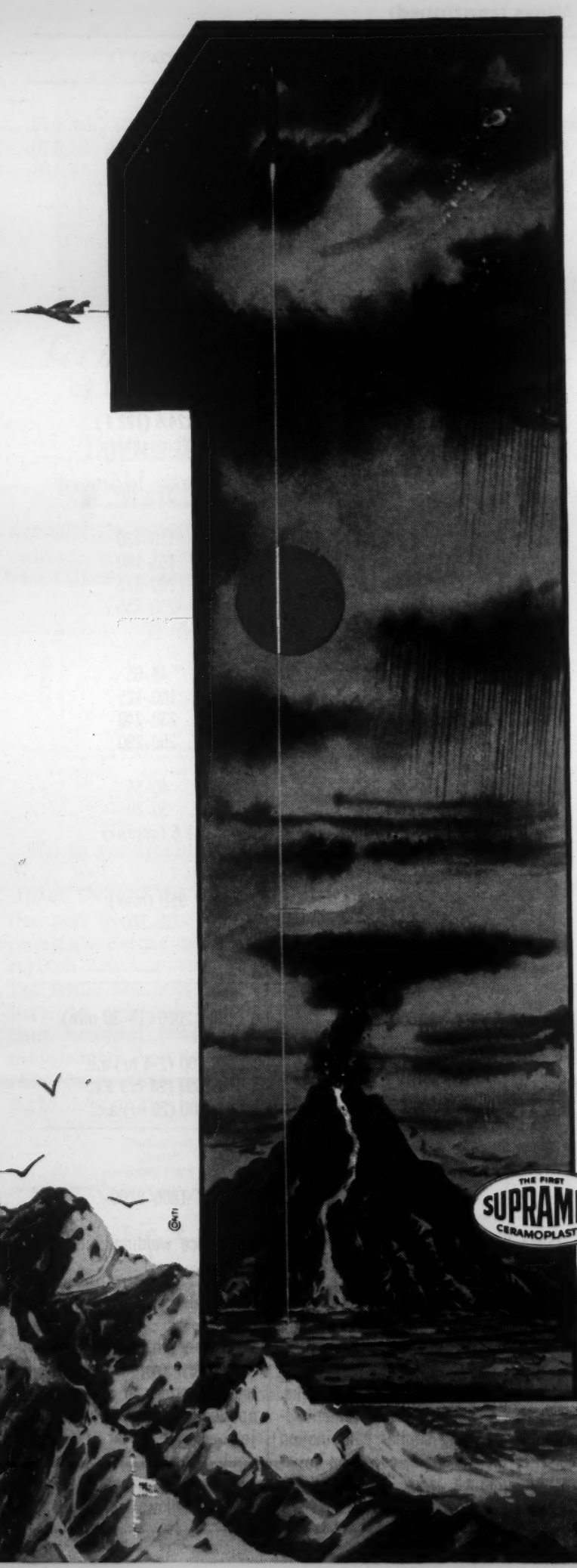

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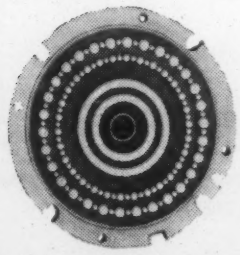

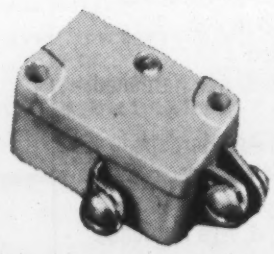

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What's new IN MATERIALS

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Dip Coatings, Chromium Cut Galling of Titanium

What's new IN MATERIALS

■ Recent investigations at both Battelle Memorial Institute and the National Bureau of Standards indicate that protective coatings can be successfully deposited on titanium. It appears that the coatings will minimize some of titanium's disadvantages, namely its oxidation at elevated temperatures and its tendency to gall when in loaded contact with itself or other metals.

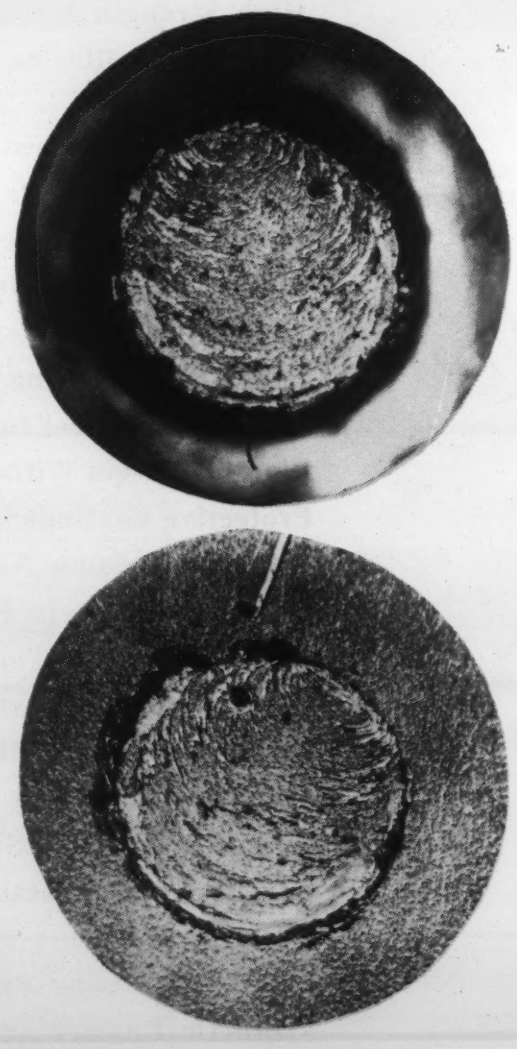
At Battelle, P. D. Miller, R. A. Jeffreys and H. A. Pray have found that both conversion and anodic coatings on titanium alloys hold lubricants efficiently and reduce galling in forming operations and in applications involving metal-to-metal contact. At NBS, C. L. Stanley and A. Brenner have found that hard, adherent coatings of nickel and chrominum increase the heat resistance of titanium.

Conversion coatings

Battelle researchers investigated a number of coatings for titanium in an effort to reduce galling. Satisfactory coatings were produced by an electrochemical anodizing process and a chemical immersion treatment. Although anodic coatings are probably as durable as the immersion or conversion coatings, the conversion coatings are more desirable from an economic and an operational standpoint.

How they're produced — Durable conversion coatings on titanium alloys were produced from three different chemical baths. Two baths were fluoride-phosphate types run at temperatures of 185 F and 80 F, respectively. The third was a fluoride-borate bath run at a temperature of 185 F. Chemical analysis of the coating obtained from the high temperature fluoride - phosphate bath showed the composition to be approximately 39 fluoride, 3 phosphate, 25 potassium and 17% titanium, indicating the formation of a potassium-titanium-fluoride complex. The coatings from the other solutions were similar in composition.

Immersion time was found to have an important effect on the thickness of the coatings. In all three baths a specific time was reached after which the coating weight remained essentially constant. A maximum coating weight was reached in both fluoride-phosphate baths at some time prior to this equilibrium point: after about 2 min in the low temperature fluoride-phosphate bath and after about 10 min in the high temperature fluoride - phosphate bath. In the fluoride-borate bath maximum coating weight was reached in 20 min.



Photomacrographs *show underside of nodule (top) and surface of test specimen (bottom) after nodule test at NBS for adhesion of heat treated chromium on titanium. The fracture has occurred in the chromium, leaving some still bonded to the titanium.*

How they perform—Titanium wire and tube drawing tests indicate that forming operations such as cupping and deep drawing are aided by the fluoride coatings. In addition, costs of operation are reduced, since the coatings are easy to apply and remove.

For instance, in plug drawing tubes with a suitable drawing lubricant, the high temperature fluoride-phosphate coating permitted successive draws with a maximum reduction of about 65%. After drawing, the coating was removed by a 30-sec dip at room temperature in a hydrofluoric-nitric acid bath; this restored a smooth, bright finish to the metal. Best drawing was obtained with a Ti-75A tube. In four passes the tube was reduced 66.5%, with only slight signs of galling on the fourth pass.

Wire drawing tests showed that the immersion coatings improved the drawing properties of titanium considerably. No annealing was required for any of the specimens tested. In one instance, as many as 17 passes were made for a total reduction of 94%. Recoating was necessary after about three passes were made.

Two kinds of wear tests were used to evaluate the immersion coatings: 1) a reciprocating wear test that simulates the sliding motion of many parts (see Table 2); and 2) a high speed rotary wear test that produces shearing forces and a different type of motion (see Table 3).

In the reciprocating wear tests (run at 70 tons per sq in.) con-

ducted on a modified shaper, the coatings appeared to form a smooth, highly polished surface layer between the ball and the base metal, and they markedly improved the response of titanium to the high pressure contact of moving steel.

The rotary wear tests were conducted on a machine that forced two cylindrical button type titanium specimens against a lapped steel disk under pressures from 50 to 800 psi. At pressures as low as 200 psi untreated titanium seized instantly on the steel. Satisfactory running times with the conversion coatings were achieved only by using a proper lubricant (one part molybdenum disulfide, two parts epoxy-phenolic resin).

Chromium coatings

The NBS process successfully electrodeposits hard, adherent chromium coatings on titanium. This is done by forming a titanium fluoride film on the metal surface, electroplating with chromium, and then heat treating the plated specimen at 1470 F.

How they're applied — The Bureau obtained the best plate by pretreating the titanium to form a coating of titanium fluoride before chromium plating. The pretreatment consisted of 1) cleaning and drying, 2) immersing the titanium in a solution of hydrofluoric and acetic acids for 10 or 15 min, 3) passing a 60 cycle alternating current through the metal for 10 min, and 4) rinsing. The metal was then transferred to a conventional chromium plating bath where it was plated at a temperature of 185 F and a current density of 120 amp per sq dm.

This procedure seems to prevent the formation of an oxide. When the pretreated metal is placed in the plating bath the titanium fluoride dissolves, permitting the chromium to bond directly to the base metal.

Heat treatment — Tensile strength tests indicate that adherence of the chromium coating to titanium is greatly improved by heat treating the plated speci-

How Conversion Coatings Perform

TABLE 1—RESULTS OF WIREDRAWING TESTS

Coating	No. of Coats	No. of Passes[a]	Final Condition
Bare	—	0	Galled
	—	0	Galled
Flucride-Phosphate (185 F)	2	8	Smooth
Fluoride-Phosphate (80 F)[b]	7	17	Smooth
	3	7	Galled
	1	7	Smooth
Fluoride-Borate (185 F)	2	8	Smooth
	3	8	Smooth

[a]Various drawing lubricants such as molybdenum disulfide were used in the tests.
[b]Heat treated 1 hr at 800 F.

TABLE 2—RESULTS OF RECIPROCATING WEAR TESTS

Coating	Wear Plate Material	Load, psi	No. of Strokes to Galling
Bare	Steel	400	1
	Bare titanium	600	4
Oxidized	Steel	2500	4500
Fluoride-Phosphate (185 F)	Steel [a]	400	15
		2500	1,018,298[c]
	[b]	2500	1,156,898[c]
	Bare titanium	600	8
	Fluoride-Phosphate (185 F)	550	17
Fluoride-Borate (185 F)	Steel	2500	79,581

[a]Air oxidized 3 hr at 800 F.
[b]Air oxidized 5 hr at 800 F.
[c]Tests were stopped before galling occurred.

TABLE 3—RESULTS OF ROTARY WEAR TESTS

	Finish	Load, psi	Running Time, hr	Coefficient of Friction	Final Condition
Not Lubricated	Bare	200	0	—	Galled instantly
	Fluoride-Phosphate (185 F)	400	0.01	—	Galled
			3.6	0.047	Galled
		600	6.7	0.014	Galled
Lubricated	Bare	600	0.67	—	Galled
			0.73	—	Galled
	Fluoride-Phosphate (185 F)	600–800	199.0	0.017	Undamaged
		600	161.5	0.062	Undamaged
	Fluoride-Phosphate (80 F)	600–800	225.0	0.072	Undamaged
		800	273.0	0.069	Undamaged

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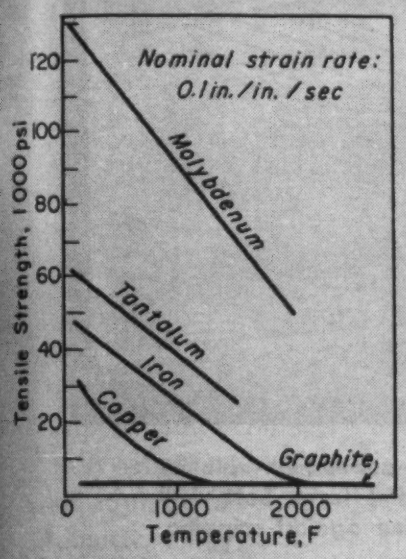
Tensile Strength, 1000 psi

men for 2 min at 1470 F in an inert atmosphere. The bond strength of heat treated specimens ranged from 4000 to 18,000 psi. Although the highest value obtained was somewhat below the tensile strength of heat treated chromium, fracture occurred in all cases in the chromium plate and not between the two metals.

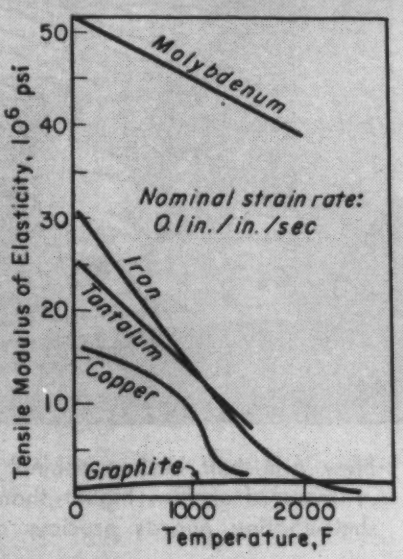
Coatings on titanium consisting of 0.02 mm of chromium plus 0.15 mm of nickel were found to be moderately adherent without heat treatment, but not comparable to chromium on steel. Procedures for depositing nickel and copper on titanium that are similar to the process for depositing chromium have been formulated. However, the nickel and copper deposits have not adhered as well as chromium and have frequently blistered.

What's new IN MATERIALS

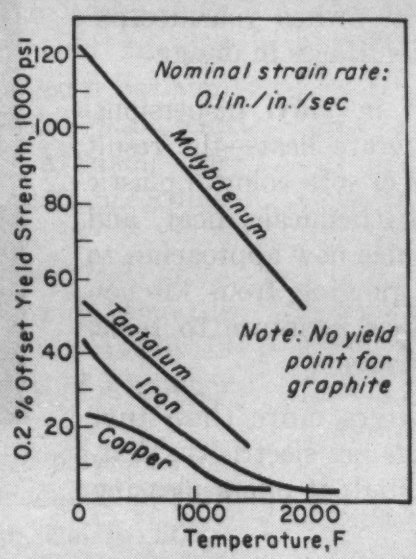
Effect of temperature on . . .



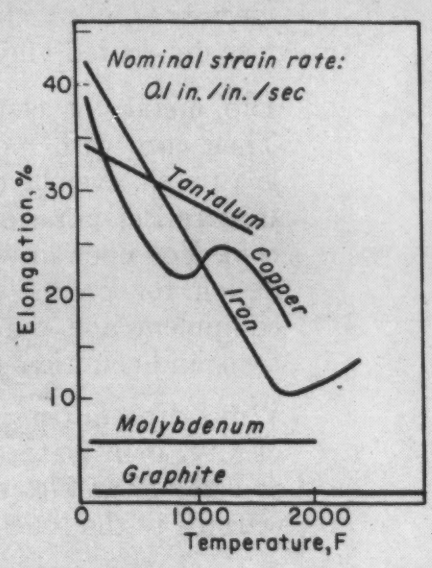
Tensile strength



Tensile modules



Yield strength



Elogation

Properties of Materials at Very High Temperatures

■ Although there has been much conjecture concerning the structural stability of high speed missile components that are exposed to aerodynamic heating, little or no specific information is available on the mechanical properties of structural materials operating under actual conditions involving rapid heating to very high temperatures, short times at high temperatures, and moderate to rapid rates of loading. Nevertheless, proper design and selection of materials for high speed missile components is dependent to a large extent upon this knowledge.

To uncover new data along these lines, J. R. Kattus, of Southern Research Institute, examined the short time tensile, creep and fracture properties of iron, copper, molybdenum, tantalum and graphite at temperatures approaching their melting points. In general, he found that none of the materials tested had optimum properties for a wide range of operating conditions. For periods up to 5 min, the load carrying abilities of tantalum and molybdenum exceed those of iron and copper at equal temperatures, although the excellent thermal properties of copper are a distinct advantage. However, because of rapid oxidation, the service life of tantalum and molybdenum is severely limited at high temperatures. Graphite, on the other hand, has relatively low strength at room temperatures, but retains this strength with increasing temperatures.

As a result of the investigation, the author suggests that if suitable protective coatings are developed for tantalum and molybdenum, these metals will be promising for applications at temperatures up to the range 4000-5000 F. Some specific data are given below and in the accompanying graphs.

Tensile strength—At the lower test temperatures, the strength of the test materials decreased in the following order: molybdenum, tantalum, iron, copper and graphite. (At temperatures above 3200 F tantalum's strength at slow strain rates was slightly

For more information, Circle No. 573

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Vinyl dip-coating offers more than just beauty. It insulates against electricity, heat, or cold. It muffles sound; it offers pleasing warmth to the touch.

New grill-shelf kitchen cabinet features high visibility ... even of shelves higher than eye level. Soft vinyl shelf-coating guards precious china against chipping.

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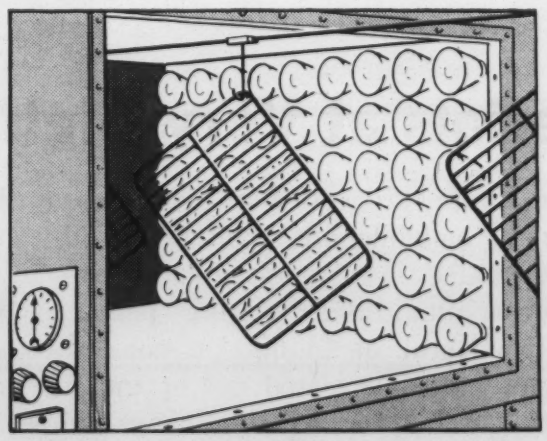
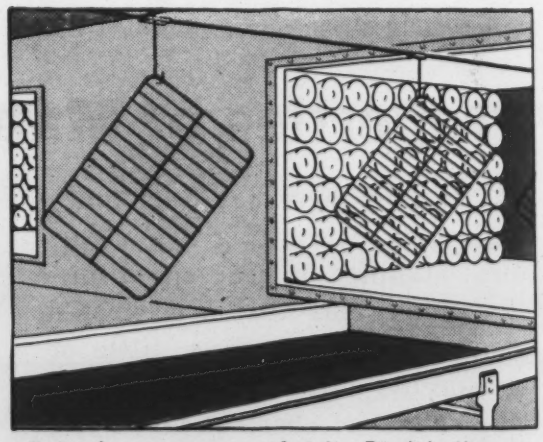
Consult your supplier for exact formulation—Your supplier can "tailor" the vinyl formulations to your exact requirements—speed of fusion, high-gloss or matte finish, resistance to soapy water, and many others. You have wide latitude in choice of processing characteristics and product traits.



Pre-heat to control thickness—By adjusting temperature and pre-heating period you can, with a single dip-coat, build coating to any thickness up to 60 mils.



Bake for permanent finish—Final baking at *moderate* temperatures permanently fuses the vinyl to metal. No further finishing is required ... *color* is an integral part of the coating.

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higher than that of molybdenum). All the materials decreased in strength continuously with increasing temperatures. The strength properties of all the metals were higher at rapid strain rates than at slow rates.

Modulus of elasticity—With the exception of a reversal in positions of iron and tantalum at the lower temperatures, the relative order was similar to that of the tensile strength properties. As in the case of strength properties, the modulus values of the metals decreased continuously with increasing temperatures. The modulus of graphite remained constant or increased slightly with increasing temperatures.

Elongation—At room temperature the ductilities of tantalum, copper and iron were about equal and considerably higher than that of molybdenum. Graphite had no plastic elongation at any of the test temperatures. With increasing temperatures, tantalum and iron decreased in elongation and then increased, as shown in the accompanying graph.

Creep properties—Results of the creep test show that the short time creep rupture properties of tantalum and molybdenum are superior to those of iron and copper at the same temperatures. The molded graphite showed remarkable creep strength; at 4750 F it supported a load equivalent to two-thirds its room temperature tensile strength for more than 5 min.

Fracture properties—The lower the stress, the higher the temperature to which the specimens could be heated before they ruptured. In all of the metals at all stress levels, the rupture temperature increased with increasing heating rates.

(The above information was originally presented at the 11th annual meeting of the American Rocket Society in November.)

Tough, stable and heat resistant:

A Promising New Plastic

■ A low cost, formaldehyde polymer that is said to combine high tensile strength, toughness, high melting temperature, fatigue life and dimensional stability with solvent resistance and resistance to deformation has been announced by the Polychemicals Dept., *E. I. du Pont de Nemours & Co.*, Wilmington 98, Del.

Called Delrin acetal resin, the polymer is still in an early stage of development. Should current field evaluation lead to a decision to build a commercial plant, the polymer would be available for unlimited sale in 1959, according to company officials.

Available as cylindrical granules measuring ⅛ x ⅛ in., the acetal resin is being made in natural color, white and a number of standard colors.

Two experimental polymers are currently being produced in pilot quantities. One is Delrin 500X, described as a general purpose injection molding resin; the other is Delrin 150X, described as a general purpose extrusion resin.

Tests indicate that the acetal resin may find application for aerosol bottles, gears, tumblers, telephone handsets and bases, pipe, bearings, automobile parts, housewares and wire coating. The material can be fabricated by injection molding, extrusion, blow molding and machining.

TYPICAL PROPERTIES

Property	500X	150X
Elongation, %		
—68 F	13	38
73 F	15	75
158 F	330	460
Izod Impact Strength, ft lb/in.		
—40 F	1.2	1.8
73 F	1.4	2.3
Tensile Strength (and Yield Point), psi		
—68 F	14,700	
73 F	10,000	
158 F	7500	
Flexural Modulus, psi		
73 F	410,000	
170 F	190,000	
250 F	90,000	
73 F, 100% R.H.	360,000	
Flexural Strength, psi	14,100	
Shear Strength, psi	9510	
Heat Distortion Temp, F		
264 psi	212	
66 psi	338	
Water Absorption, %		
24 hr Immersion	0.4	
Equilibrium, 50% R.H.	0.2	
Specific Gravity	1.425	
Rockwell Hardness	M94, R120	
Flammability, in./min	1.1	
Melting Point (crystalline), F	347	
Flow Temperature, F	363	
Deformation Under Load (2000 psi, 122 F), %	0.5	
Compressive Stress at 1% Deformation, psi	5200	
Coef of Ther Exp, per °F	4.5×10^{-5}	
Taber Abrasion (1000 gm, CS-17 wheel), mg/1000 cycles	20	
Thermal Conductivity, Btu/hr/sq ft/°F/in.	1.6	
Specific Heat, Btu/lb/°F	0.35	

Molybdenum Sheet Now Stocked

Pure molybdenum sheet is now available from warehouse stocks at *Fansteel Metallurgical Corp.*, North Chicago, Ill. The company says this is the first time molybdenum sheet has been available from stock.

The warehouse stock is made up entirely of Moly "D" sheet, said to be a premium grade of molybdenum with good ductility, malleability and deep drawing qualities. Ordinarily supplied in the annealed state, the sheet is stocked in seven thicknesses ranging from 0.005 to 0.025 in. thick.

(more What's New on p 154)

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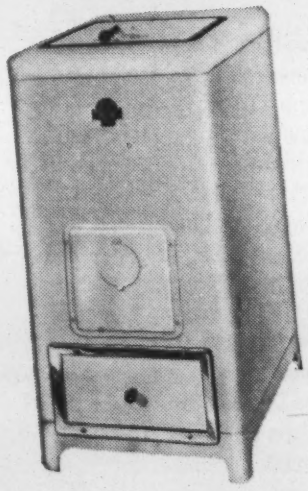

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What's new IN MATERIALS

Nylon Extrusions: New Resins, New Sources

Barrett and Du Pont have recently announced new nylon resins developed chiefly for extrusions. A new source for general purpose nylon extrusions has also been established.

1. Caprolactam resin

A polycaprolactam type nylon compound called Plaskon Nylon 8201 has been developed by *Barrett Div., Allied Chemical & Dye Corp.*, 40 Rector St., New York 6, N. Y., for extrusion and blow molding. In general, the properties of the new compound are similar to those of Plaskon Nylon 8200 (see M&M, May '55, p 108). However, the high molten viscosity of this new resin is said to minimize shrinkage in thick sections and to eliminate voids, thereby improving extrusions and moldings.

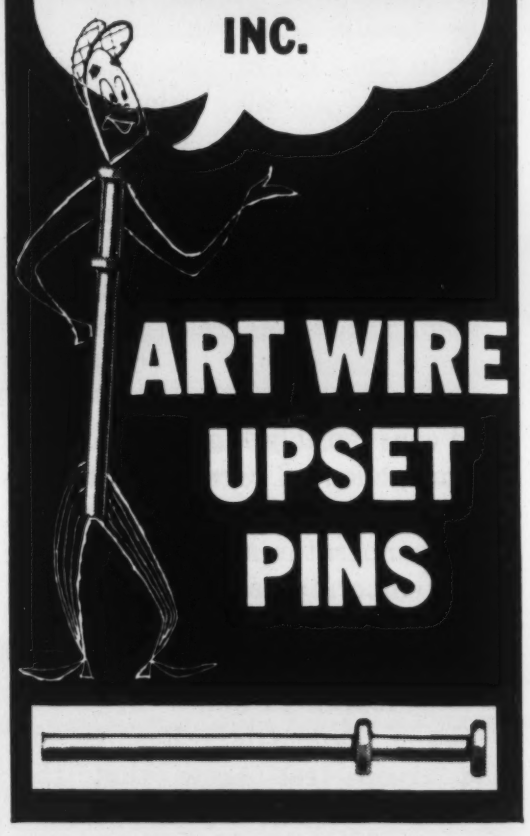
The new compound makes it possible to obtain the polycaprolactam properties in the form of relatively thick films and tapes, as well as small diameter rods and tubing. The high viscosity molding compound is also suitable for blow molding of bottles with high pressure capacity. Plaskon Nylon 8201 is recommended for general purpose extrusions and moldings; in addition, a heat stabilized form is available for high temperature and wire covering applications.

The material is recommended for such things as packaging, bottles of all types, food containers, wall paneling, hot water piping, door channels, fuel lines, wire covering and compressed air lines.

2. Tough nylon resin

Another nylon resin for extrusions has been developed by *E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept.*, Wilmington 98, Del. Called Zytel 42, its properties are approximately the same as those of Zytel 101, a general purpose nylon powder, but its

"Simplifies assembly... Improves performance" SAYS: SARKES TARZIAN, INC.



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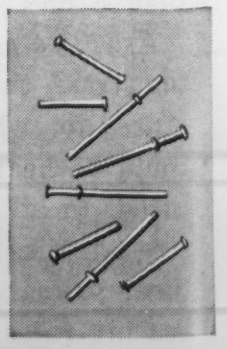

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Attention! All Users of Nickel Alloys...

New Driver-Harris Vacuum Melting Service Now in Operation

After many years of experience with vacuum melting programs, Driver-Harris now offers a complete vacuum melting service for almost all of the 132 special purpose alloys made by this company.

The specific benefits gained by vacuum melting in the production of nickel-chrome alloys are today clearly established. They are:

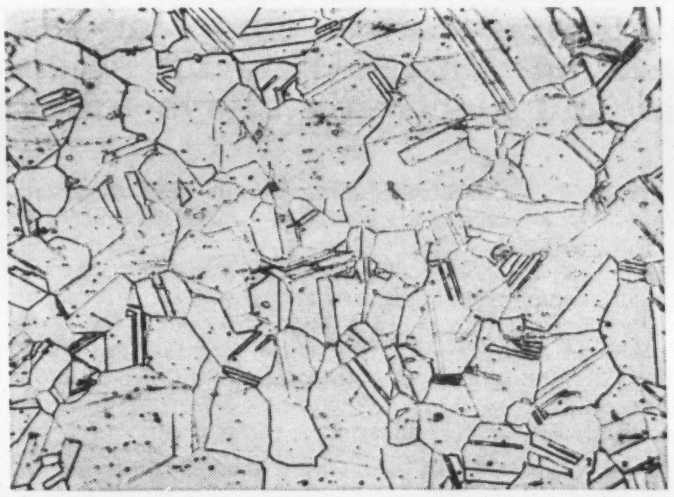
1. Much closer control of analysis—particularly in alloying with the highly reactive elements, Titanium, Aluminum, Columbium, Calcium, and Zirconium. The normally high affinity for nitrogen and oxygen these elements have is completely eliminated in vacuum melting, thereby opening new avenues in alloy production.

2. Great reduction in inclusions, especially oxides and nitrides, results in higher ductility and tensile properties. In fine wires, the improvement in properties is frequently so great that wire sizes may be reduced without sacrifice of strength. An example of the greatly improved microstructure is illustrated in the metallographs shown.

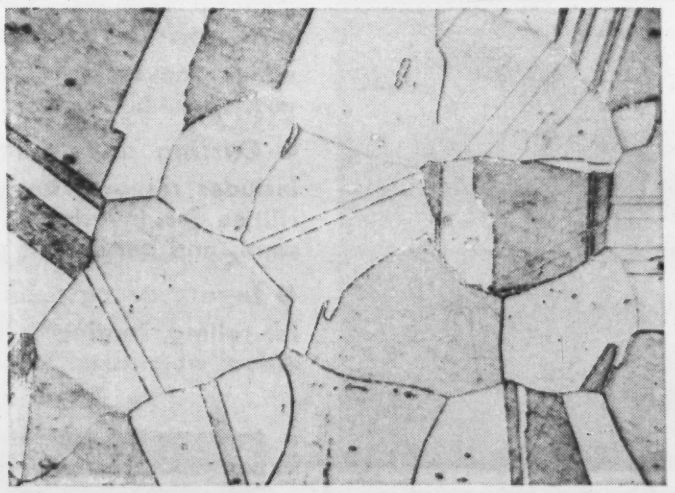
3. Complete elimination of gas, not from the surface only but from the entire mass. Alloys so produced are therefore more desirable in the manufacture of electron tubes.

4. General improvement in electronic, electrical, and mechanical properties to meet specifications. Because closer control of analysis is a primary advantage of vacuum melting, we can now achieve these specific improvements with remarkable certainty.

Almost all of the Driver-Harris Alloys now vacuum melted and processed under close physical and analytical control show improvement in one or more of the above ways. If you are seeking further improvements in the D-H Alloys you use, inquire now for information on how Driver-Harris Vacuum Melting Service can help you. Address your inquiry to Dept. VMS.



Polished and etched sample of Air Melted NICHROME V in annealed condition.*



Vacuum melted NICHROME V, annealed. Note that reduced inclusions result in much larger grain size for the same annealing treatment.

*T. M. Reg. U. S. Pat. Off.

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BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario

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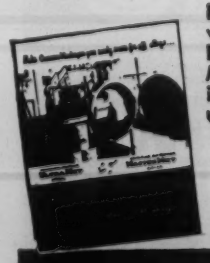

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What's new IN MATERIALS

TYPICAL PROPERTIES OF ZYTEL 42

Tensile strength, psi	11,200-12,600
Elongation, %	100-200
Modulus of Elasticity, psi	400,000
Shear Strength, psi	9600
Izod Impact Strength, ft lb/in.	1.1-1.5
Stiffness, psi	200,000
Flexural Strength, psi	13,800
Compressive Stress at 1% Deformation, psi	4900
Creep in Flexure[a]	90
Hardness, Rockwell R	118
Flow Temperature, F	480
Coef of Ther Exp, per °F	5.5×10^{-5}
Ther Cond, Btu/hr/sq ft/°F/in.[b]	1.7
Specific Heat, Btu/lb/°F	0.4
Deformation Under Load (122 F, 2000 psi), %	1.4
Heat Distortion Temperature, F	
264 psi	150
66 psi	360
Dielectric Strength, v/mil	
Short time	385
Step-by-Step	340
Volume Resistivity, ohm-cm	4.5×10^{13}
Dielectric Constant	
60 cycles	4.1
10^3 cycles	4.0
10^6 cycles	3.4
Power Factor	
60 cycles	0.014
10^3 cycles	0.02
10^6 cycles	0.04
Water Absorption, %	1.5
Flammability, in./min	Self-extinguishing
Specific Gravity	1.14
Compression Ratic	2.14

[a]A measure of deformation under a prolonged standard load. Results here represent mils deflection in 24 hr of ⅛ x ½-in. bar with 4-in span center-loaded flatwise to 1000 psi, minus initial deflection.
[b]Measured by Cenco-Fitch apparatus.

toughness properties are different. The new resin has an elongation of 107 to 217%, compared to 45 to 71% for Zytel 101. Izod impact strength is 0.7-1.1 ft-lb per in. at —40 F and 3-6 at 73 F.

The material is being made in the form of cube-cut extrusion powder at the company's Washington Works near Parkersburg, W. Va. It is recommended for use in tubing, rods, pipe and sheeting. Film of Zytel 42 may be laminated to paper, foil and to other films.

3. Extruded rods, tubing

United States Gasket Co., 608 N. 10th St., Camden, N. J., is offering a nylon molding com-

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NO REASON WHY YOU CAN'T DO IT, TOO!

Typical of the Mueller Climatrol line is this summer air conditioner and gas-fired winter air conditioner, now uniformly painted electrostatically with RANSBURG NO. 2 PROCESS

MUELLER CLIMATROL,
Milwaukee, increases paint mileage 40% with
RANSBURG NO. 2 PROCESS

And, 10 men averaging 40 hours a week now do the work formerly handled by 24 men averaging 50 hours!

Painting used to be a bottleneck in the manufacture of heating and air conditioning equipment at Mueller Climatrol.

But not any more!

When Mueller modernized its finishing department—replacing hand spray with Ransburg No. 2 Process Electro-Spray—daily production was increased . . . finishing costs were cut . . . and quality of the work was improved.

Annually, Mueller coats over 10 million square feet of sheet metal, so a 40% increase in paint mileage—translated into paint dollars saved—is a sizeable figure. Pointing up other savings, a typical run of 400 furnace casings used to take 200 man hours to clean and hand spray. Mueller does it now in 60 hours!

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What's new IN MATERIALS

pound called Chemiseal Nylon 101 in the form of extruded rods from 1/16 to 3 in. dia and extruded tubing from 5 mils o.d. to the largest sizes produced commercially. The nylon material is resistant to heat, abrasion, chemicals, solvents, oils and greases, and is said to be the least expensive of standard nylon molding compounds.

Wear Resistant Coatings Compared

A comparison of the wear resistance of different surface coatings used in reconditioning machine parts appears in the Jan '56 issue of the Russian machinery journal, *Vestnik Mashin.* An English interpretation of the Russian test results is given by W. G. Cass in the July '56 issue of *Iron & Steel* (British).

Ten sets of test pieces were used in the test. Two pieces were left untreated and were used as a basis of comparison for the coated pieces. One untreated test specimen was normalized whereas the other test piece was normalized and tempered. Eight different treatments were used and are outlined in the table below.

Diameters of the two untreated

Surface Treatments

Normalized, electro-fused, and worked (39)
Normalized, h.f. hardened, electro-fused, and worked (39)
Normalized, smooth chrome plated, and worked (39.7)
Normalized, porous chrome plated, and worked (39.7)
Normalized, electrolytically iron plated, and worked (39.7)
Normalized, sandblasted, metallized, and worked (38)
Normalized, electro-spark treated, metallized and worked (38)
Normalized, electro-spark treated, metallized, heat treated at 752 F for 20 min and air cooled (38)

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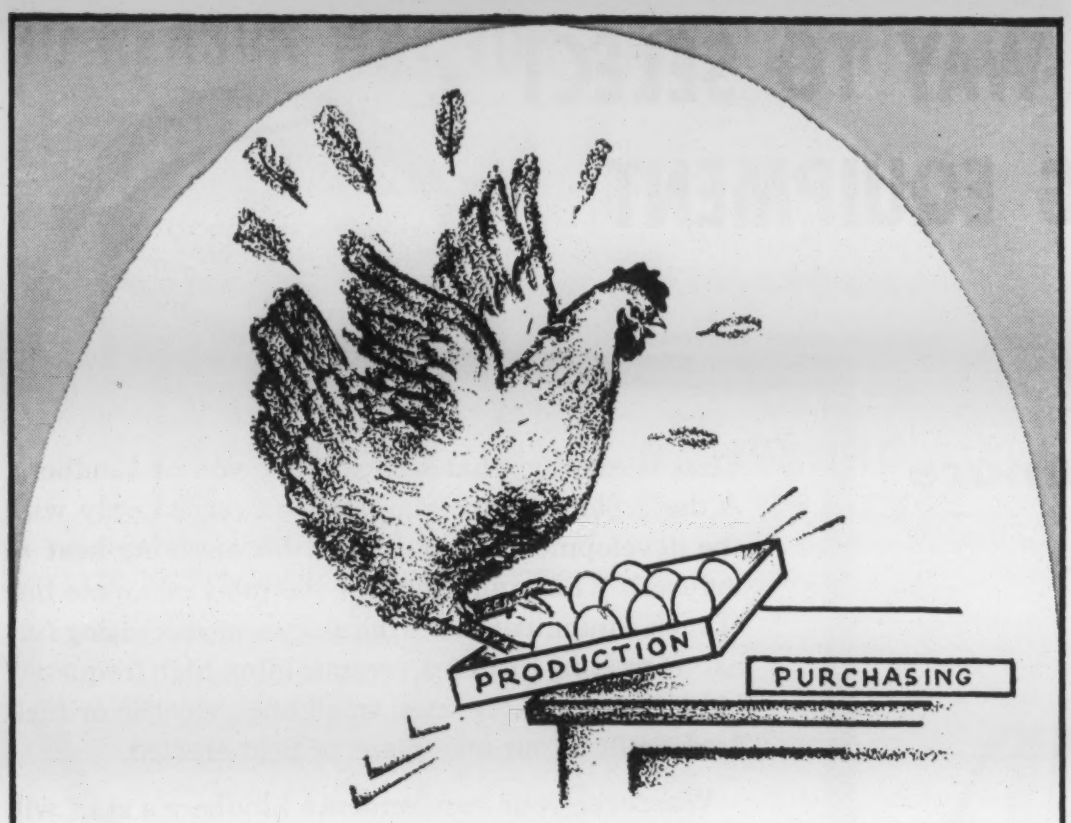

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pieces measured 40 mm. The eight test pieces were coated up to 40 mm to match the untreated specimens. Diameters of the test pieces before treatment are shown in parentheses in the table.

A universal Amsler machine was used for the test, but in place of the top roll, a cast iron block or shoe was substituted. A special lubricant was employed to ensure reasonably quick "running-in" and stability of friction conditions, including load, speed of rotation, and temperature. The lubricant used was kerosene, used alone and with various amounts of grease, fed at a rate of 10 drops per min. Load on the test piece was the maximum possible and speed of rotation was 193 rpm. The block had an axial reciprocal movement of 2-mm strokes and a speed of 220 rpm.

Wear was measured by loss in weight of the test specimen. Running-in was continued until constant friction movement and temperature were attained. The test usually lasted 4 hr. Microstructure and hardness of the base material and coating were also studied.

Time required for reaching constant weight, by soaking in hot Avtol beforehand, for the various test pieces ranged from 3 to 18 hr, except for the smooth chromium plated piece and the uncoated specimens, which showed no change in weight.

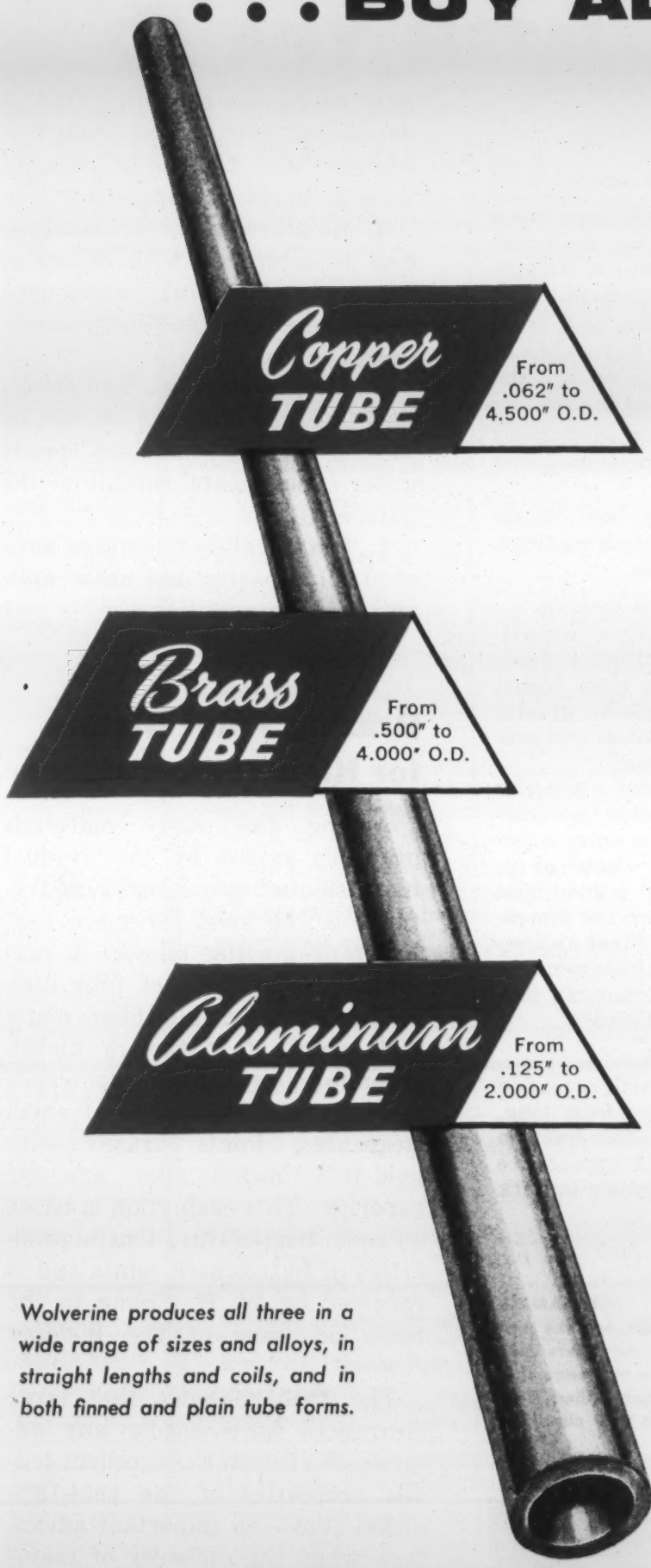
Results

Test results showed exceptional behavior for the metallized test pieces. Other surface treatments showed a definite increase or accumulation of wear after each hour of work. But with metallized specimens, although they showed a marked change in weight during the first 5-6 hr of immersion, showed little weight change during the period from 11 to 18 hr.

Conclusions (not to be regarded as final) from the test are:

1. All the tested coatings, ex-

. . . BUY ALL 3 FROM 1



Wolverine produces all three in a wide range of sizes and alloys, in straight lengths and coils, and in both finned and plain tube forms.

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▲ ▲ ▲

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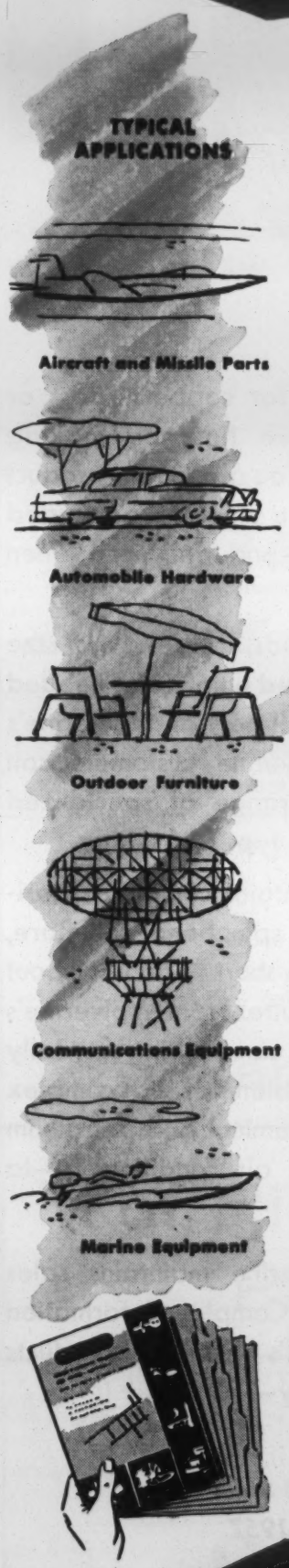

EASE OF USE—Iridite is a simple chromate conversion treatment. Fast, easy, economical. You just dip, brush or spray it on the part at room temperature. No special equipment. No specially trained personnel.

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Two specially formulated finishes that give you maximum latitude in aluminum treatment. Both provide excellent corrosion protection and paint base. Iridite #14-2 is an improved product that allows greater flexibility in operation and coating thickness and produces the optimum in corrosion protection.
Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

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Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

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cept the iron electroplates have a wear resistance exceeding that of normalized steel, and may be recommended for use in reconditioning machine parts.

2. Metallized sprayed coatings may be compared with the chromium plated coatings when used under lubricated frictional conditions.

3. All the coatings, except the smooth chromium, can be run or worked in with sufficient speed; under experimental conditions the time is 1-2 hr.

4. The metallized coatings have good oil capacity and show high anti-friction qualities.

Brazing Filler Metals for High Temperatures

Among the many materials problems raised by the gradual increase in operating temperatures is the need for more heat resistant brazing alloys. A preliminary evaluation of four high temperature brazing filler materials shows that though nickel-chromium-base filler materials yield satisfactory joints at small clearances, joints brazed with gold-18% nickel alloy are far superior. This evaluation is based on room temperature tensile properties of butt-brazed joints and is reported by W. H. Chang in the Sept '55 issue of the *Welding Journal*.

The author shows that large clearances have hardly any adverse effect upon the excellent tensile properties of the gold-18% nickel alloy—an important advantage when the difficulty of maintaining "zero" clearance in practical applications is considered. In addition, the gold-18% nickel alloy is free from liquation, thus imposing no particular requirements on the heating rate during brazing. Finally, since nickel is the only oxidizable element in this binary alloy, oxidation resistance

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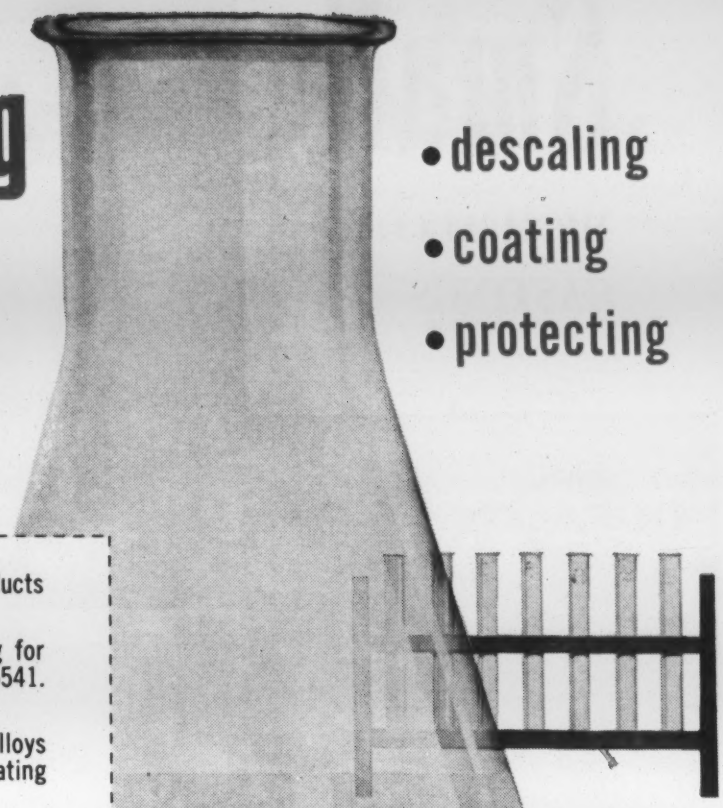

ALUMINUM	**DESCALING:** Complete line of deoxidizing and polishing products for all alloys of aluminum. **COATING:** Economical and "quick fixing" conversion coating for application by spray, dip or hand methods. Approved to MIL-C-5541. Insures paint adhesion, stops aluminum corrosion. **PROTECTION:** Alkali-removable protective film for aluminum alloys both during storage (in plant and outdoor) and during fabricating practices.
STEEL	**DESCALING:** Complete line of alkaline and acid descaling media. **COATING:** Full line of iron, zinc and manganese phosphate compounds to provide a tight coating for better adhesion of organic finishes and for oil absorption. These materials all meet the various requirements of applicable government specifications. **PROTECTION:** Versatile group of products for protection of parts from the elements.
TITANIUM	**DESCALING:** Approved and accepted process for conditioning and removing scale from all current titanium alloys, both after heat forming to 1150° F. and heat treating to 1750° F. **COATING:** Acceptable anti-galling and seizing conversion coating for the major alloys of titanium. Also used as base for lubes. Requires no post-heat treatments. **PROTECTION:** Easily removable coating to protect titanium against tightly adhering scale up to 1600° F. during hot forming or heat treating.
STAINLESS STEEL	**DESCALING:** Process for completely removing heat scale from various alloys (including 17-7 PH). **COATING:** Easily removable coating to protect stainless steel against tightly adhering scale up to 1600° F. during hot forming or heat treating.
MAGNESIUM	**DESCALING:** Non-electrolytic alkaline process for removing previous chrome pickle films as well as oily substances often found on magnesium. **COATING:** One-package powdered product which, when in solution with water, replaces Dow #17 treatment. Requires no mixing of chemicals. Eliminates chance of human error. **PROTECTION:** Single-package touch-up liquid to produce coatings equal to Dow #18 treatment. (Note: All magnesium processes mentioned above are approved for use by Magnesium Department, Dow Chemical Co.)

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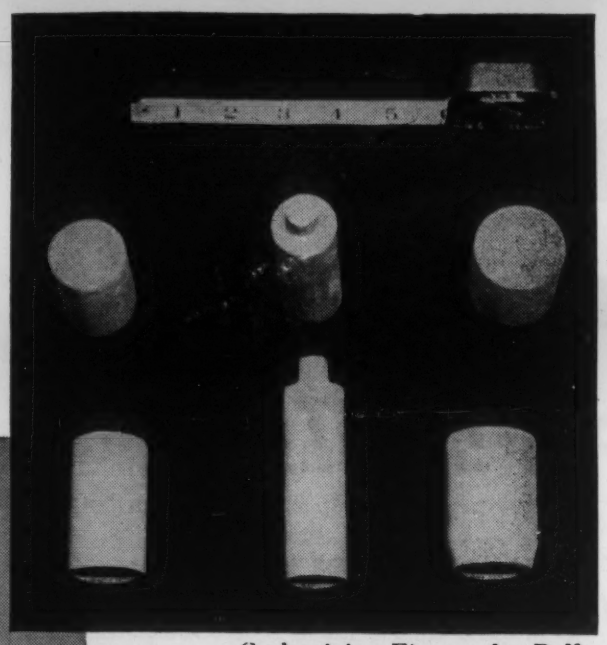
Small

HIGH ALLOY
CASTINGS

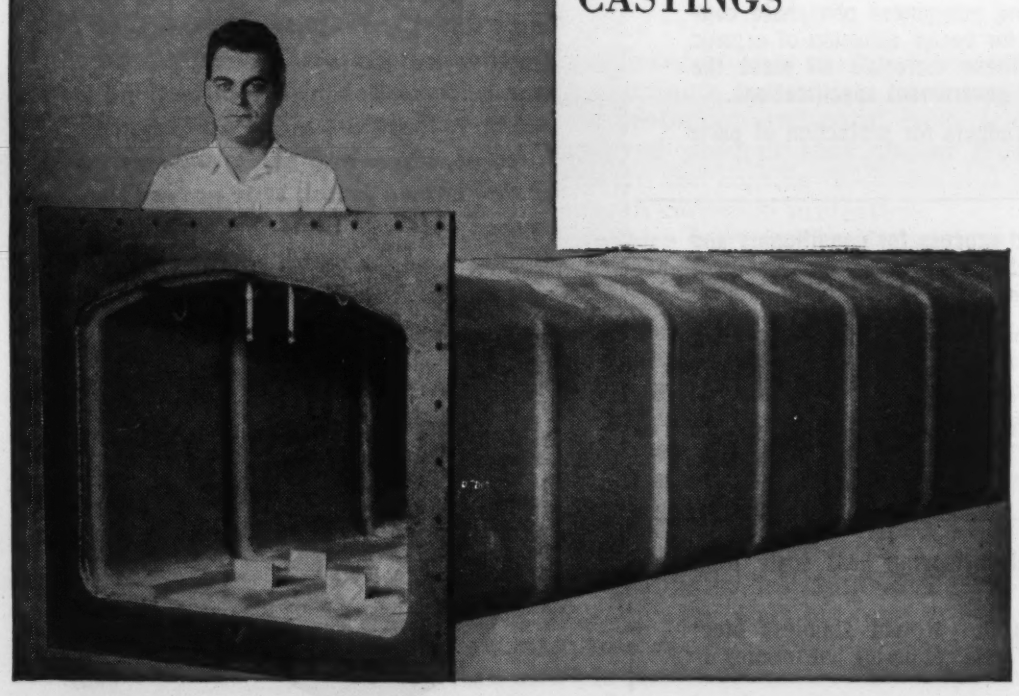


Carburizing Fixture for Ball Bearings 1½" diameter—
Analysis 35% Ni — 15% Cr

DURALOY

Large

HIGH ALLOY
CASTINGS



Muffle for Continuous Strip Annealing
12' 6" long — Analysis 38% Ni — 18% Cr.

LARGE or small DURALOY, can do it! These are just typical examples of the work moving through our foundry. Some of these castings are designed for heat resistance, some for corrosion resistance, some for abrasion resistance; all are cast by experienced foundrymen. All are carefully tested in our up-to-date laboratory.

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of the joints brazed with the gold-18% nickel alloy may not be much different than that of the joints brazed with the nickel-chromium filler materials.

On the other hand, there are certain shortcomings. For one thing, this material is expensive. More important, it has a low melting point (1742 F) which limits service temperature and hence the area of application. It also presents difficulties in heat treating brazed parts.

Brazing procedure

The other materials tested were two nickel-chromium-boron filler materials and a nickel-chromium-silicon material. Brazing was performed in a hydrogen atmosphere without a conventional flux. Specimens were machined to required shape and vapor degreased. (Visual inspection and microscopic examination revealed little difference in extent of flow and microstructure between as-ground and grit blasted surfaces.) The matching units of each specimen were assembled by tack welding at the four corners of the joining area and subjected to the following brazing treatment:

1. A 2-min nitrogen purge.
2. A 5-min hydrogen purge.
3. Heating at the desired temperature for a prescribed length of time with a hydrogen flow of 25 cfh.
4. Cooling for 45 min.
5. A 1-min nitrogen purge.

Results

In general, tensile properties of the joints were more consistent when brazed for 30 min than when brazed for 5 min. A brazing time of 10 min was used with the gold-18% nickel alloy since, with no brittle phases involved, prolonged diffusion was not necessary to improve joint properties. Excellent strength and ductility were maintained with clearances ranging up to 0.006 in.

Tensile properties of joints brazed with the nickel-chromium boron alloys were extremely sen-

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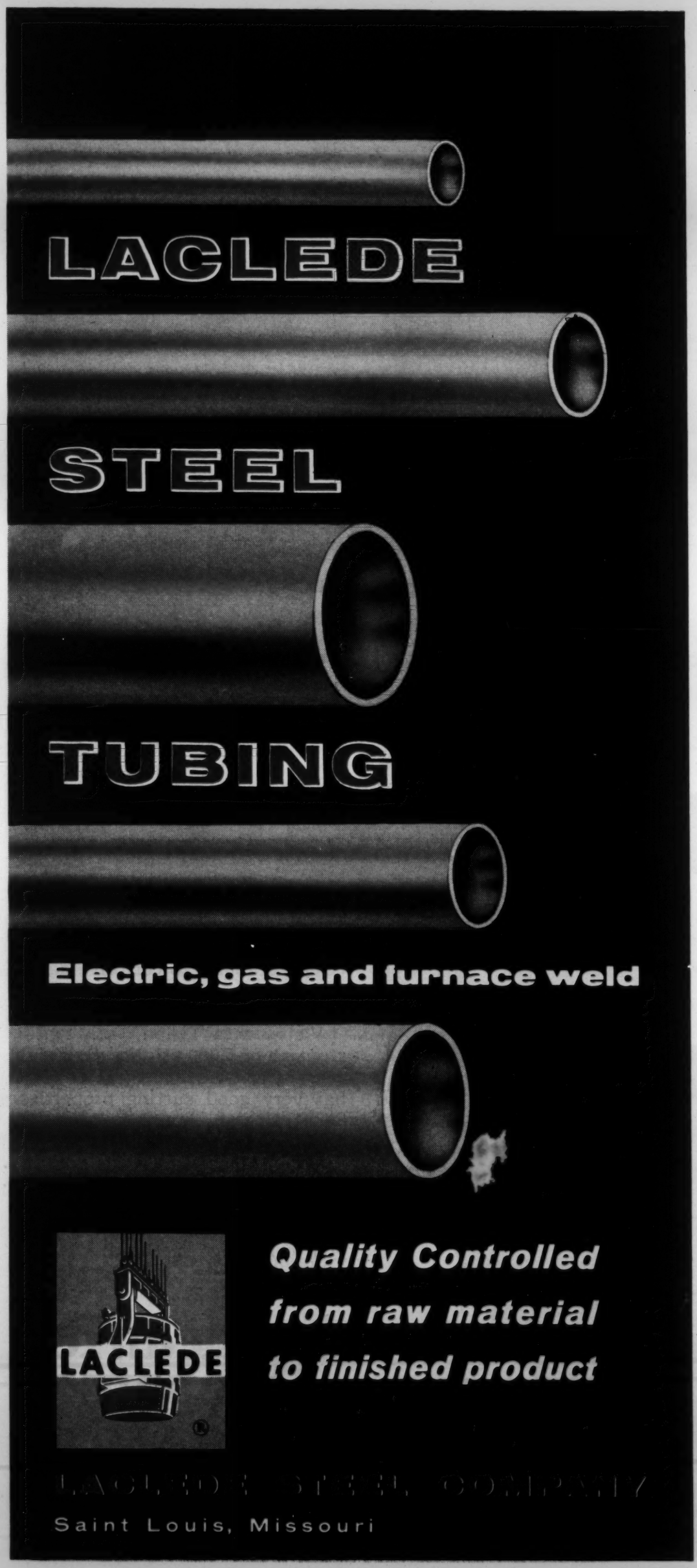

sitive to joint clearances. Joint properties progressively deteriorated as clearance was increased. At zero clearance, butt joints brazed with nickel-chromium-boron and nickel-chromium-silver possessed satisfactory tensile properties. At clearances of 0.002 in. and above, tensile strength diminished to 30-70% of that at zero clearance.

The difference in sensitivity to clearances is explained as follows: At zero clearance alloying elements that might otherwise form brittle phases merely diffuse into the base metal and do not form a continuous layer. At larger clearances brittle phases form readily unless the filler metal neither contains brittle phases nor forms such phases with the base metal.

The author also found that the boron-containing filler materials cause intergranular penetration of the base metal which appears to be more extensive the more complex the base material. There are indications that this type of penetration does not occur in base materials which do not contain alloying elements. Stable borides are formed in such materials as chromium, molybdenum, tungsten and cobalt.

Chromium Carbide Die Aids Brass Extrusion

A chromium carbide die is capable of duplicating the production of 20 dies formerly used for the hot extruding of brass. Use of the dies also allowed Mueller Brass Co. to operate its extrusion lines on the automated basis originally planned. The problems overcome include unpredictable product size and varying hardness after subsequent drawing operations. Tolerances are now held within 0.006 in. for free machining brass rod by using a type 608 chromium carbide die.

(more What's New on p 168)

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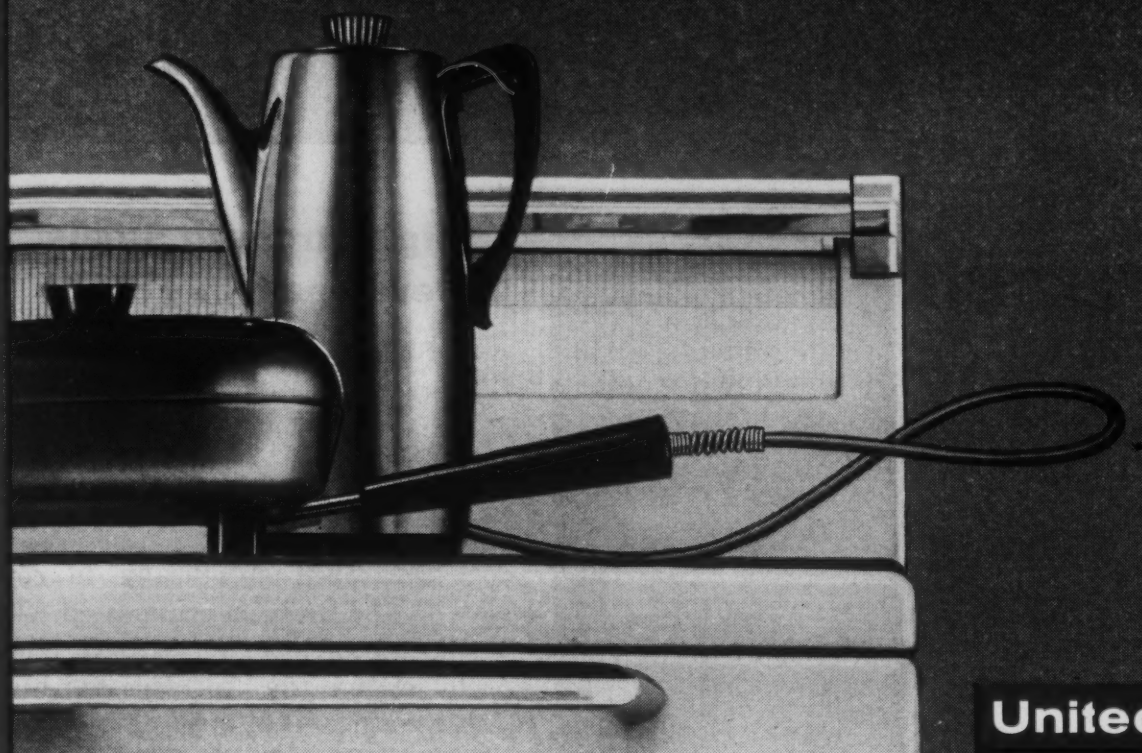

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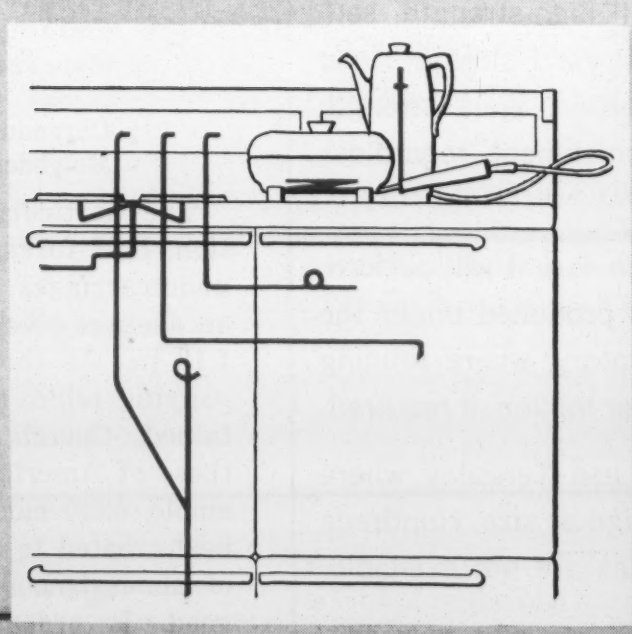

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Federated Tenzaloy is the most widely used of all high-strength, self-aging aluminum alloys because it has the highest yield strength, and it has the best all-around combination of properties. Yield strength is the true measure of a metal's ability to take punishment, regardless of other claims that are made.

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What's new IN MATERIALS

High Strength Steels Developed in France

Special steels with considerably higher strength-weight ratios than previously available in France have recently been developed for use in that nation's aircraft.

Developed specifically to cope with the problems connected with the use of steel in aircraft (thus following the pattern of high strength-weight steel development in the United States), the new compositions not only meet high mechanical requirements but also take into consideration size and shape of the parts to be made and the amplitude of deformation which can be tolerated. Composition of the new steel, as given in an article in the June '56 issue of *Les Aciers Fins & Speciaux*, is:

Carbon	0.37
Silicon	0.24
Sulfur	0.015
Manganese	0.43
Nickel	3.88
Chromium	1.80
Molybdenum	0.50

The particular parts in question, half forks and caissons for undercarriages of aircraft, have an average thickness of less than 1.18 in. As shown in the accompanying table, the properties obtained, though not as high as those of American steels (for example, 4330 modified steel can be heat treated to a tensile strength of about 250,000 psi), are quite good. In order to achieve these properties the forged parts are machined in three separate operations, each followed by a heat

MECHANICAL PROPERTIES OF NEW FRENCH STEELS

Property \ Part	Half Forks	Caissons
Ten Str, psi	178,000	173,000
Ten Str, psi	132,000	133,700
Elong, %	9.4	9.3

Naugatuck MARVIBOND

Marvinol vinyl-to-metal laminating process

glamorizes even everyday articles

MODERN PRODUCT DESIGN seeks to combine eye-catching beauty with functional durability. And Marvibonded vinyl-to-metal laminates do just that! Two excellent examples are the "Thunderbird" ice chest and picnic jug, manufactured by Poloron Products, Inc.* Their almost indestructible fabric-embossed vinyl finish is fused to aluminum sheets by the Marvibond† Process, then formed into the shells of extremely lightweight, glass-fiber-insulated food and drink containers that are as eye-appealing as they are practical.

Marvibonded laminates enable manufacturers to add the colorful beauty, texture and wear-resistance of vinyl to the structural strength of metal for an ever-widening range of products... from business machines to auto and bus interior panels... from TV cabinets to telephone booths! Sheets of steel, aluminum, magnesium or copper, *prefinished* by the Marvibond Process, can be shaped, sheared, drilled and punched on standard sheetmetal-working equipment without damage to the flexible vinyl surface.

We do not make Marvibonded laminates or the products shown here, but we have licensed many laminators throughout the country to use the Naugatuck-developed Marvibond Process. We'll gladly give you the names and addresses of several licensees near you.

*Poloron Products, Inc., New Rochelle, N.Y.

†U. S. Pat. No. 2,728,703

For the Plastics Industry, Naugatuck Chemical manufactures MARVINOL® polyvinyl chloride resins, VIBRIN® polyester resins, KRALASTIC® high-impact rubber resins, Curing Agents for epoxide resins and Blowing Agents for foamed plastics.

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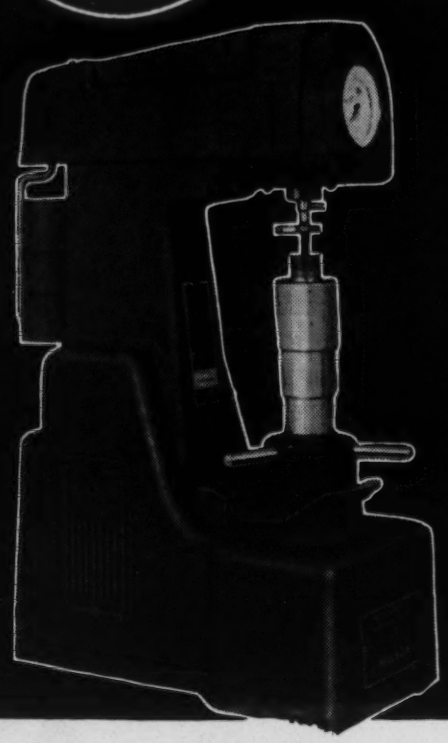
Wilson "Rockwell"* Hardness Testers

Tests with INCREASED SPEED... Accurately



Y Model Motorized Hardness Tester

Requires fewer operating steps... *Because*

IT'S MOTORIZED

• Here is the motorized operating procedure made possible by the new WILSON "Rockwell" Y Model Motorized Hardness Tester—

1 Place specimen upon anvil or table.

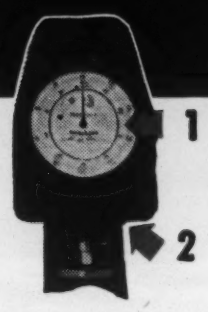
2 Elevate test piece into test position. (With the new Set-O-Matic Dial Gauge, the large pointer will then automatically point to zero.)

3 Tap depressor bar to apply Major Load. When Major Load is fully applied, the Motorized Mechanism takes over—completes the test cycle—removes the Major Load.

4 Read "Rockwell" Hardness Number. Then, lower elevating screw to remove test piece.

For complete information about the WILSON Y Model, or any others of the complete line of WILSON "Rockwell" Hardness Testers, write or call today. A WILSON hardness testing expert is available to consult on your specific requirement.

**Trade mark registered*



Illuminated Dial Gauge

(1) Affords clear and easy reading. Readings are easily taken wherever your "Rockwell" Tester is located—whatever the lighting conditions of the room.

Indenter light (2) is directed towards the test area, making it easy to locate the exact area of test at all times.

Set-O-Matic Dial Gauge

The Set-O-Matic Dial Gauge increases the accuracy of the test, makes the test cycle shorter and increases the number of readings obtainable within a definite period of time.

ACCO

Wilson Mechanical Instrument Division

AMERICAN CHAIN & CABLE

230-E Park Avenue, New York 17, N. Y.

for Better Value

For more information, turn to Reader Service Card, Circle No. 425

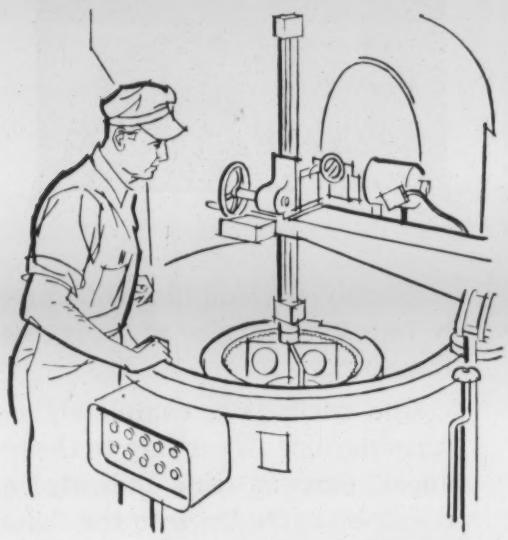
treatment to stabilize them by eliminating internal stress. The entire operation is as follows:

1. Rough machining to within 0.12 in. of the final dimensions.
2. Air hardening followed by softening and stabilizing temper.
3. Second rough machining to within 0.02 in. of final dimensions.
4. Stabilizing temper.
5. Third semi-finishing operation, a certain allowance being left for correction.
6. Final utilization treatment: air hardening and tempering at a low temperature. In order to avoid superficial decarburization during heating, the final treatment is conducted in a salt bath.

Polyethylene Resins for Clearer Films

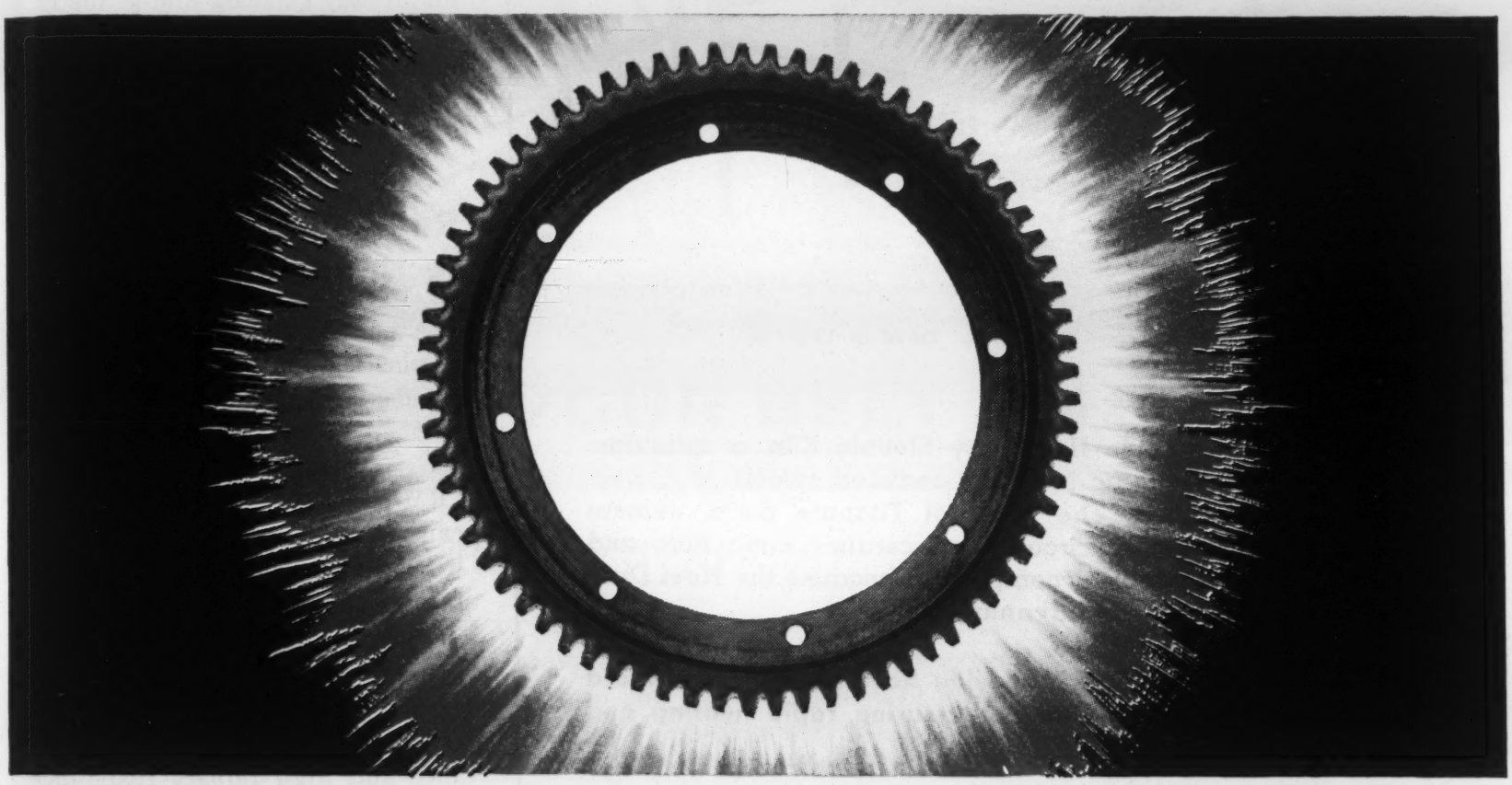
Two new film-grade polyethylene resins intended for packaging applications have been announced by *Bakelite Co., Union Carbide & Carbon Corp.*, 260 Madison Ave., New York 16, N. Y. The resins are said to make pos-

***Clarity** of polyethylene packaging films made from new resins is compared here. Bottom view is through newest and clearest film.*



IH Saves $82,507 Per Year

with TOCCO* *Induction Hardening*



Gears, shafts, pins, wheels, tubes and bars—almost any size or shape of part—or any metal, too—is adaptable to TOCCO hardening, brazing, annealing or heating for forging.

Production Up—Engineers at the Milwaukee Works of International Harvester Company have adopted TOCCO for hardening final drive gears for famous International Harvester farm tractors. TOCCO increases production on the gear shown here from 14 to 35 per hour, 250% faster than conventional heating method, reduces job from a 3 shift to 2 shift operation, even with increased production schedule. Heating time is 35 seconds; oil quench, 60 seconds.

Costs Down—TOCCO cuts cost—saves $82,507 per year on application shown above. TOCCO makes possible use of C-1050 A.R.R. steel instead of expensive A-8645-H alloy steel previously required. TOCCO also eliminates shot-blast, formerly needed to remove scale, and extra machining operations that used to be necessary to compensate for distortion.

Gear shown is 18½" O.D., width of face is 2", weight 34 pounds, 73 teeth. Hardness obtained is 55-66 R.C., using 140 K.W. of 10,000 cycle power.

Our Engineers can probably find applications in your plant where TOCCO can increase output and reduce unit costs.

THE OHIO CRANKSHAFT COMPANY

Mail Coupon Today—**NEW FREE Bulletin**

The Ohio Crankshaft Co. • Dept. T-2, Cleveland 5, Ohio

Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating".

Name_____

Position_____

Company_____

Address_____

City_____ **Zone**____ **State**_____

For more information, turn to Reader Service Card, Circle No. 372

NEW ELECTRONIC CERAMICS FIRED IN A HEVI DUTY KILN

Conveyor Furnace with a 5" wide, 66" long muffle, through which a 4" wide belt travels Rated at 18.5 KW

With a versatile Hevi Duty Electric Kiln, a manufacturer of electronic ceramics reduced rejects to a negligible amount. The firing of Titanate parts, cement coatings, printed circuits and ceramic capacitors and resistors is easily accomplished because the Hevi Duty Kiln offers these advantages:

★ **UNIFORM TEMPERATURE** Long life heating units are placed on all sides of the work chamber assuring rapid heating and even heat distribution.

★ **ZONE TEMPERATURE CONTROL** provides accurate temperatures for critical firings. A preheat and cooling chamber prevents thermal shock.

★ **ATMOSPHERE CONTROL** An alloy muffled heating chamber permits the use of reducing or special atmospheres. Curtain burners at entrance and exit prevent contaminating atmospheres from entering the chamber.

★ **VARIABLE SPEED DRIVE** The drive mechanism which is within easy reach of the operator, regulates conveyor speed for required time cycles.

★ **MESH BELT CONVEYOR** allows volume production with a minimum of material handling and provides extra versatility by conveying parts of various sizes and shapes.

★ **EFFICIENCY** Sturdy construction with ample layers of insulation assures low operating and maintenance costs.

SPECIAL HEVI DUTY ELECTRIC KILNS can be engineered to coordinate with production systems. Send us your specifications.

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively

Dry Type Transformers ***Constant Current Regulators***

For more information, turn to Reader Service Card, Circle No. 392

What's new IN MATERIALS

sible polyethylene film with greatly improved clarity at no increase in cost.

One resin is a completely new formulation. According to the producer, current tests indicate that it can be extruded into the "clearest film now on the market." The other resin is a modification of an already existing film-grade resin. Both films are resistant to moisture, tearing and abrasion, and retain their properties at subfreezing temperatures.

Rubber Coating Is Nonflammable

A nonflammable latex coating—a plastics and synthetic rubber blend — has been introduced by *Rubber Magic, Inc.*, 4312 Third Ave., Brooklyn 32, N. Y. Called "RM-64," the coating material can be used to protect metal, wood and masonry in vessels containing acids and salt solutions.

The coating material can be air dried or given a short 15-min bake at 250 F. The cured material is reported to have good cut resistance and high impact resistance. It has a tensile strength of 2500 psi and an elongation of 225%.

The flexible, nontoxic coating may also be used as a general protective and decorative coating for wire racks and wrought iron furniture, as a waterproof coating for wood and cardboard packages, and as a shatterproof coating for glass and other fragile articles. It is available transparent and in all colors.

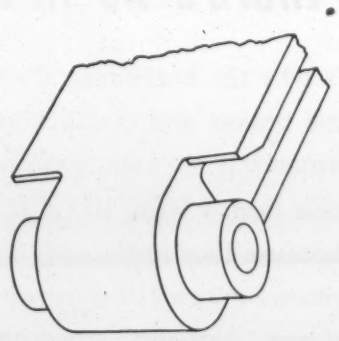
Hot Strength Improved in Nickel Aluminide

The intermetallic compound, nickel aluminide (NiAl), seems to be a promising high temperature material primarily because of its high melting point of 3000 F and low specific gravity of 6.0 gm per cu cm, coupled with excellent oxi-

TIGHTEN YOUR BELT ON COSTS!

SPECIFY HEAVY-DUTY THERMALLOY* CONVEYOR BELT

Designed by Electro-Alloys to eliminate the "crank-shafting" caused by extreme temperatures and heavy loading conditions. Short integral cast pin allows the link to adjust itself and transfer the load of the belt evenly to the rest of the links. Cast pin is approximately twice as strong in shear as the ordinary wrought alloy bar—and so designed that the bending stress is definitely lower than can be expected from the cast link of a conventional belt.

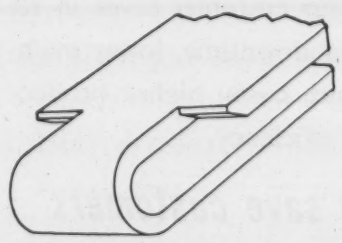


Typical heavy-duty link with cast pin.

FOR LIGHTER PARTS, SPECIFY THERMALLOY GENERAL PURPOSE

A loop-type casting design, suitable for general heat-treat applications in industry. Available in either 3″ or 4″ pitch. The 3″ pitch is a light-duty general-purpose belt, weighing 17 lbs. per sq. ft. The 4″ pitch is primarily designed for intermediate loads of somewhat larger parts, and weighs 21 lbs. per sq. ft.

*Reg. U. S. Pat. Off.



Typical 3″ or 4″ pitch center link of loop-type casting design.

WRITE FOR BULLETIN T-241

. . . giving additional design and application information on both Heavy-Duty and General-Purpose Thermalloy Conveyor Belts. Address: Electro-Alloys Division, 8022 Taylor St., Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION ELYRIA, OHIO

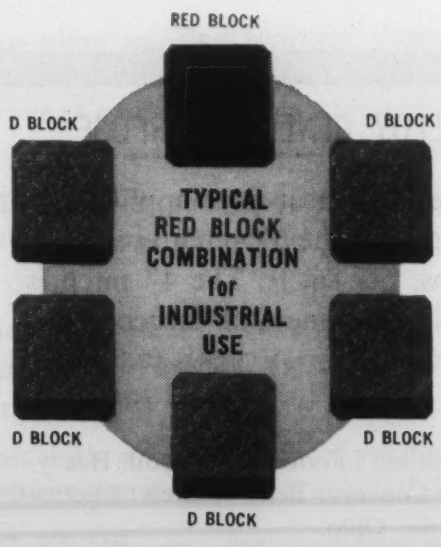
For more information, turn to Reader Service Card, Circle No. 567

....there's no in-between!

That's why the brake and clutch linings you use are important . . . because brakes and clutches are a key factor in performance, and performance is *the* main basis for judging the value of your product.

World Bestos RED BLOCK linings are the best you can use . . . best because they're the *only* linings that supply *guaranteed no-fade performance even under stepped-up operating conditions.* RED BLOCK brakes give "pinpoint" stopping power at highest operating temperatures . . . outlast other brake blocks by margins of 600% and more!

Your customer saves in reduced downtime, lower maintenance costs, higher production efficiency.



You save customers

● Write for full information and illustrated folder on RED BLOCK Combinations for industrial uses.

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Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Clutch Facings • Vibration Controls • Sheet Packing

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What's new IN MATERIALS

dation resistance at elevated temperatures. However, its relatively poor stress-rupture strength and elevated temperature creep properties have been deterrents to its broader use. In an attempt to improve these characteristics without sacrificing oxidation resistance, several materials have been investigated as possible stiffeners for nickel aluminide. In Technical Report 52-291 of Wright Air Development Center, W. H. Herz, American Electro Metal Corp., reported on results of these attempts, and described the most promising compositions developed.

Zirconium most promising

Of the addition materials tested zirconium was found to be the most promising in increasing high temperature strength and stress rupture life, without sacrificing oxidation resistance. The best composition is NiAl + 4% Zr. The major drawback to this composition is an inconsistency in impact strength values. Though the highest values are promising, reproducibility is poor.

Transverse rupture strength is high and increases from 130,000 psi at room temperature to 160,000 psi at 2000 F. Due to limitations of test equipment, it is impossible to predict at just what temperature strength begins to fall off seriously. Electrical resistivity is 13 to 14 microhm-cm, much lower than the 30-35 microhm-cm values of either NiAl or NiAl + 4% Ti. The 100-hr stress rupture life of hot pressed NiAl + 4% Zr specimens is approximately 17,000 psi at 1600 F, 12,000 psi at 1750 F and 9000 psi at 1800 F. Cold pressing and sintering techniques greatly increase stress rupture values over those of hot pressed specimens. For example, 100-hr stress rupture life of sintered parts is 15,300 psi at 1750 F and 12,000 psi at 1800 F.

Inconsistent impact strength

Oxidation tests at 1800 F show a weight gain of 2.9 mg per sq cm

For more information, Circle No. 590 ➤

after 260 hr. Though this rate is somewhat higher than that of straight nickel aluminum, it is still considered excellent. Also, the material retains its strength after oxidation. Room temperature transverse rupture strength measured after oxidation at 1800 F for 260 hr is about 125,000 psi, compared with 130,000 psi for pieces tested without oxidation.

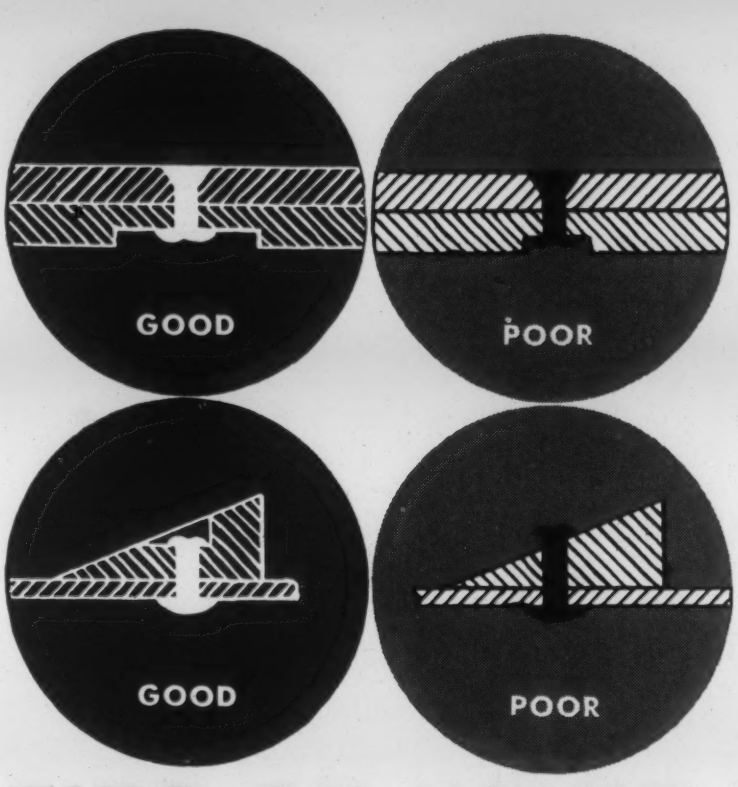
Impact strength values varied widely. Tests consisted of a form of the NACA drop impact test, as recommended in the "Meeting on Impact Testing of Cermets" at Alfred University, Feb '54. Specimens of NiAl + 4% Zr give some values in excess of 15 in.-lb with the pieces unbroken. These results are obtained at room temperature, 1800, 2200 and 2550 F. Wide scatter of values is shown by the proportion of diverse strength values obtained. Of the specimens tested (2 in. long by 0.225 to 0.250 in. sq), 20% had values over 10 in.-lb, with some over 15 in.-lb; 40% had between 6 and 10 in.-lb; and 40% had between 3 and 6 in.-lb. No correlation with any of the variables could be established.

Nonstick Coating Resists Corrosion

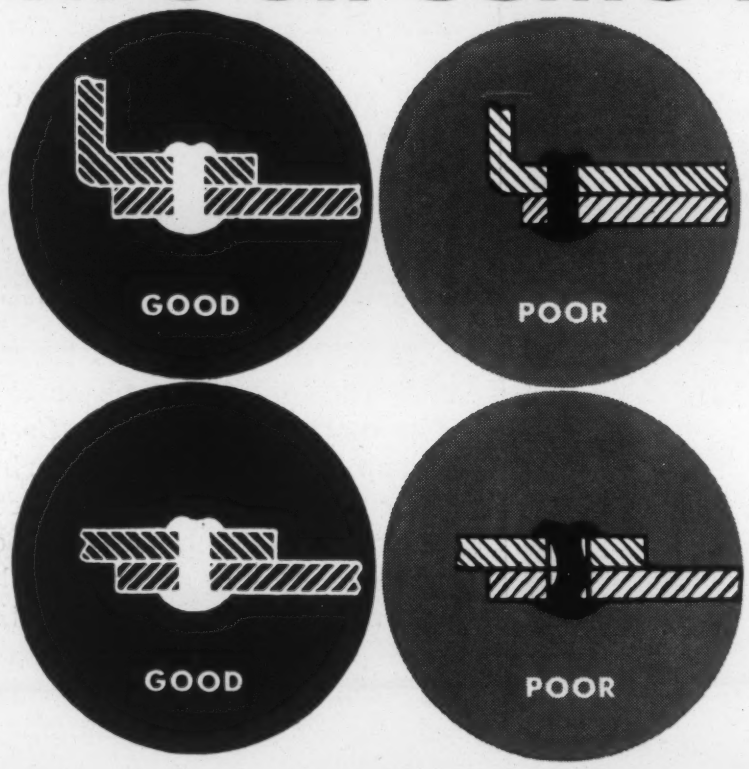
Aluminum panels coated with Selinizing Fluid have been found to withstand 2000 hr of continuous salt spray with no evidence of base metal attack or loss of adhesion. The panels were treated with a single coat of a silicone resin dispersion in compatible organic solvents produced by *Selinized Process Co.*, Houseman Bldg., Grand Rapids, Mich.

Applied by spray or other means, the coating is allowed to air dry and is then baked 1 hr at 480 F. The protective coating resulting from this treatment is said to be a hard, durable, tightly adherent, flexible transparent film.

According to the manufacturer,



TIPS ON USING RIVETS



A short design course guaranteed to save a lot of grief later on!

You could memorize these and thousands more design tips on the best use of rivets—but don't! Much simpler to call on Milford for the right answers to all your riveting design and application problems. Full-tubular, semi-tubular, split, cutlery, decorative—Milford makes them all from any metal that can be cold-formed, then adds a wide variety of platings and finishes.

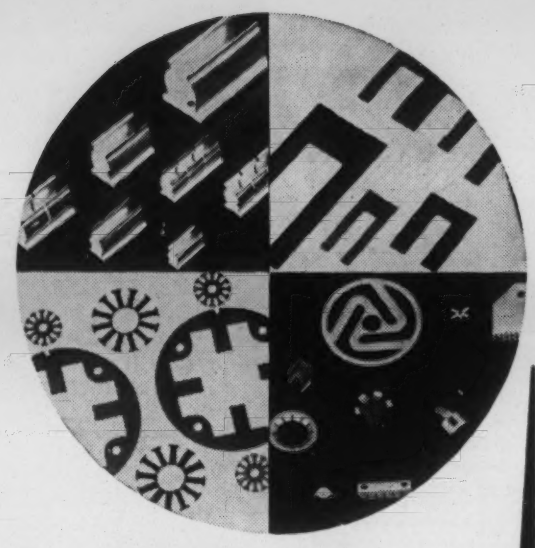
To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

For more information, turn to Reader Service Card, Circle No. 400



Can 0.0005 inch precision strip simplify your product design?

From 0.0005 in. to 0.040 in. thick and 0.090 to 6 in. wide, these alloys are available as special-tolerance strip:

Beryllium Copper
Phosphor Bronze
Nickel Silver
Brass
Chromium Copper
Stainless 17-7PH
Invar
Magnetic: High Nickel

Some immediately available. Others rolled to order in 2 to 21 days. Can be supplied in coils or straight lengths with slit or filed edges—also cadmium plated.

Write for Bulletin 7 TODAY.

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Los Angeles *KRUSEN WIRE & STEEL CO.*

For more information, Circle No. 423

What's new IN MATERIALS

the dispersion can be applied to a wide range of cast and wrought metals, baking temperatures as low as 250 F being possible. For normal applications the cost of the Selinizing fluid averages 2 to 3¢ per sq ft.

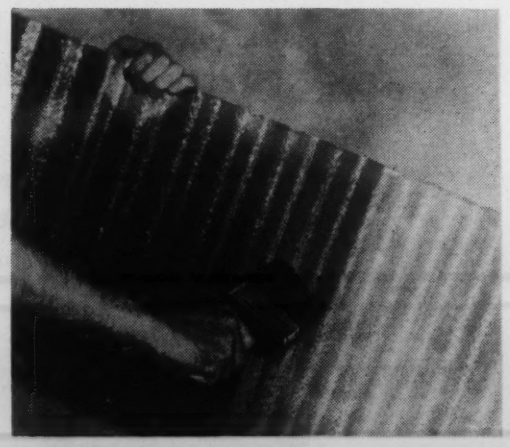
The coating is presently being used as a release agent on aluminum refrigerator trays (to keep frozen meat from sticking). The transparent coating is also said to be of interest to manufacturers of cooking utensils and appliances, since the coating permits cooking and baking without grease and prevents staining and discoloration of the metal.

Finish Renews Luster of Dull Plastics Panels

An air drying plastics lacquer that will not peel, crack or chip is available from *Resolite Corp.*, Zelienpole, Pa., for restoring luster to fiberglass-reinforced panels that have become dull or roughened by long exposure to the elements. Where desirable, the finish may be used to deepen the color of the plastics panel, reducing its light and heat transmission.

Called Resolac, the lacquer is available in clear and seven colors. It can be sprayed or brushed on a clean dry surface. A gallon covers approximately 400 sq ft.

(more What's New on p 180)



***Lacquer** being applied to a fiberglass-reinforced panel that has become dulled by exposure to the elements.*

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
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Blackmer Pump Co., Grand Rapids, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
DeLaval Steam Turbine Co., Trenton, N. J.
Empire Pattern & Foundry Co., Tulsa, Okla.
Florence Pipe Foundry & Machine Co., Florence, N. J.
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Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co., Chicago, Ill.
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Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
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Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

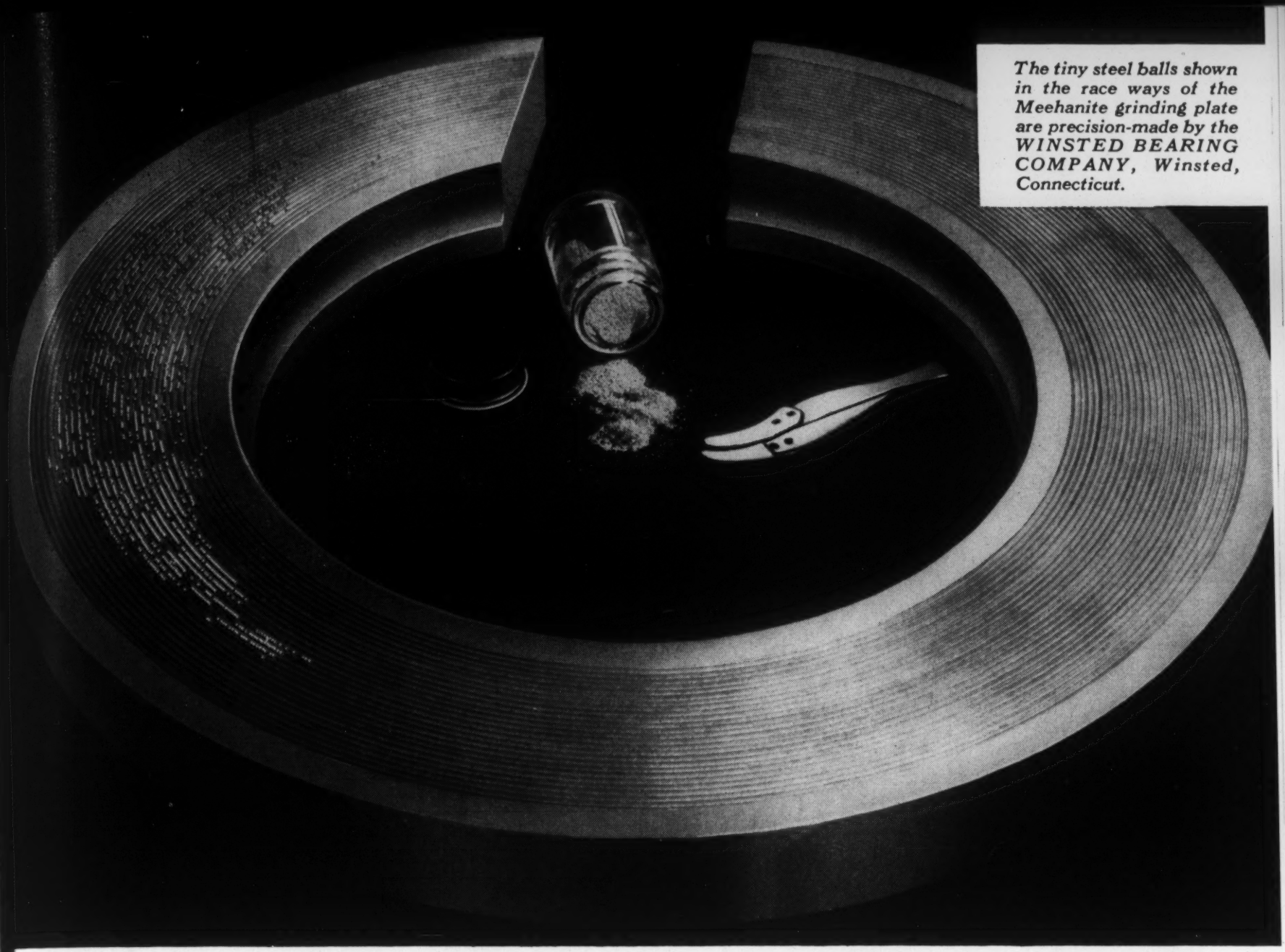
SEND FOR FREE BULLETIN

"Casting Soundness Can Be Controlled"

Write today to Meehanite Metal Corporation, Department 1A, 714 North Avenue, New Rochelle, New York.

MEEHANITE®

For more information, Circle No. 556



The tiny steel balls shown in the race ways of the Meehanite grinding plate are precision-made by the WINSTED BEARING COMPANY, Winsted, Connecticut.

Miniature steel balls are ground perfectly round on grinding plates cast in Meehanite metal

The fine grain structure and uniform solidity of Meehanite grinding plates enable the Winsted Bearing Company of Winsted, Connecticut to make miniature steel balls to the exacting requirements of the precision industries.

These exceptionally dense grinding plates, cast in quality controlled type "GA" Meehanite metal, provide long service life, maintain dimensional accuracy and can be heat treated without fear of distortion. In addition, Meehanite plates have high tensile strength (over 50,000 psi), high modulus of elasticity, low co-efficient of thermal expansion, excellent wear resistance and good machinability.

The tiny steel balls shown are used in miniature bearings, ball point pens and other precision instruments. They are made with the highest degree of uniformity and dependability. Each ball must be spherical within three to four millionths of an inch, can vary in size no more than five millionths of an inch and the surface finish must be better than half a micro-inch.

Meehanite grinding plates have been used by the Winsted Bearing Company for over six years with very satisfactory results.

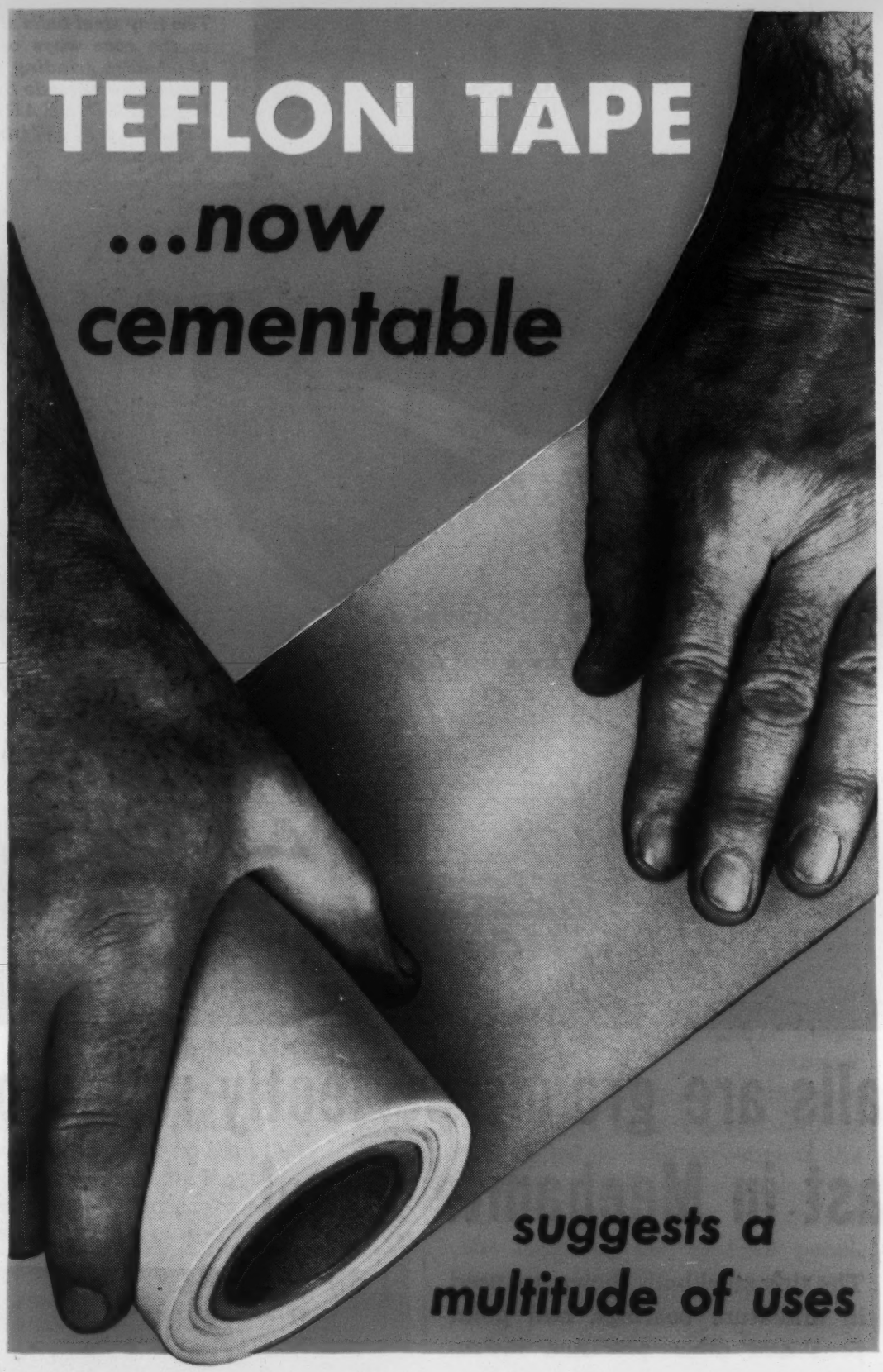
If you would like more detailed information about the physical properties of Meehanite casting, write today for Bulletin AR-130 "Casting Soundness Can Be Controlled."

Over 20,000 steel balls ground perfectly round on Meehanite grinding plates are held in the teaspoon. The hermetically sealed glass jars contain over 50,000 balls.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION NEW ROCHELLE NEW YORK



■ Now, "the material that sticks to nothing" can be cemented to anything (metal, glass, wood, plastics, etc.) with ordinary commercial adhesives (including the pressure-sensitive). Pull test approximately 45 lbs.

This new, treated tape (down to 5 mil. thickness) offers the opportunity for inexpensive, thin-section applications of this material for many services where *TEFLON's unusually frictionless sanitary surface, zero water absorption, broad service temperature range (—110° to 500°F), chemical inertness and high dielectric properties are desired.

Cementable TEFLON Tape, 5 mil. to 60 mil. in thickness is available in continuous rolls up to 12 in. wide. Sheets are also available 1/32-in. thick in sizes to 24 x 24 in.; 1/16-in. thick in sizes to 48 x 48 in.

Now—if the problem says "TEFLON", price ceases to be a factor. Specify Cementable TEFLON Tape.

*du Pont Trademark

UGS **UNITED STATES GASKET CO.**
CAMDEN 1, NEW JERSEY

For more information, turn to Reader Service Card, Circle No. 436

What's new IN MATERIALS

Glass-Polyester Lining for Food Containers

A glass fabric-reinforced polyester laminate has been developed by *Conolite Div., Continental Can Co.*, 205 W. 14th St., Wilmington 99, Del., for lining bins, freezers, tanks, trucks and similar food storage and shipping containers.

Designated Conglas, the lining material is said to be resistant to alcohol, mineral acids, vegetable oils, salt water, weak alkalies, toluol, heptane and carbon tetrachloride. The white, flexible lining is also said to retard fungus and mold growth, and it is nontoxic. The material can be applied to surfaces with contact adhesives, epoxy adhesives and mastics.

The 36-in. wide material is available in sheets and rolls up to 150 ft in length. According to the producer, it can replace stainless and enameled steels or painted plywood where moisture and food acids have been a problem.

ASTM Specs Best for Specifying Rubber

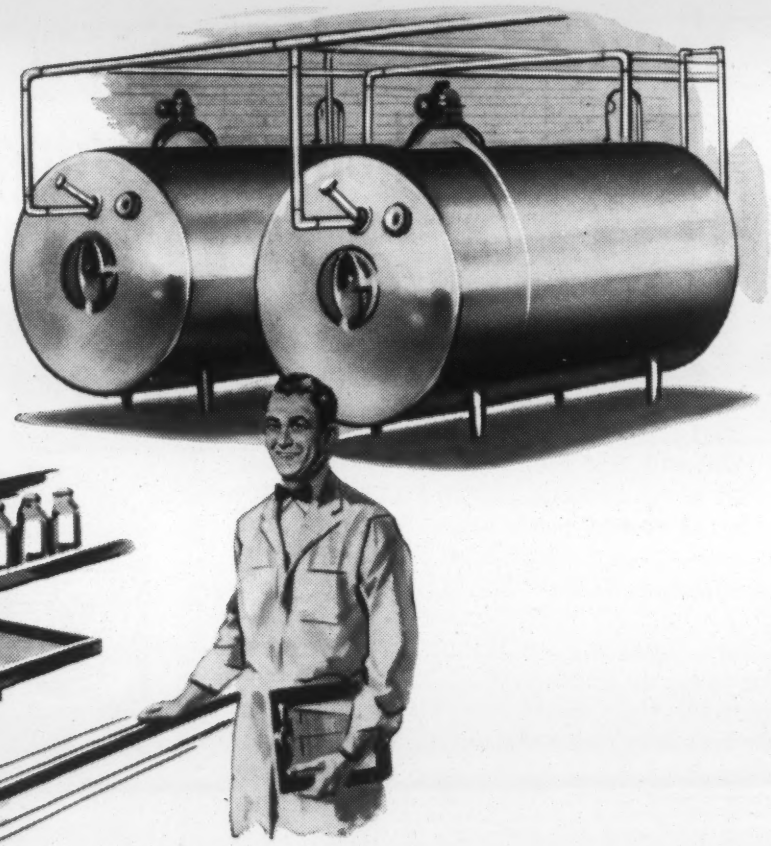
Dr. Giuseppi Bruni of Milan, Italy, said some years ago that "the rubber industry is like a semipermeable membrane; a lot comes in from the outside but very little gets out from the inside." This statement seems, to a degree, to be true today. As a result, the prospective buyer of rubber parts may have some difficulty in getting the kind of information he wants from the rubber manufacturer.

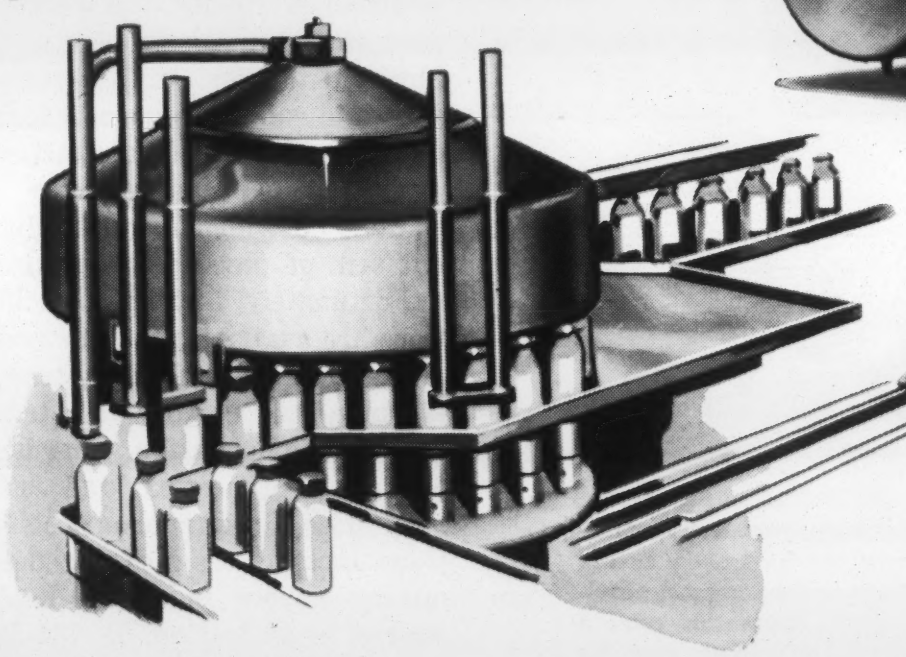
The solution to this problem is to use ASTM rubber specifications to specify rubber parts, according to Raymond B. Stringfield, consulting engineer of Los Angeles, who spoke at a recent Pacific Area Meeting of the ASTM. These specifications are not concerned with the composition of the rubber compound, which the rubber manufacturer would often prefer not to

from cow to container . . .

stainless steel

safeguards the purity of your dairy products





Dairymen and milk-product plant operators know that Stainless Steel is the only metal that year after year effectively resists acid corrosion. It can easily be kept clean and sterile and imparts no odor in contact with the product.

Through all the stages of milking, transportation, processing and packaging Stainless Steel completely safeguards the delicate flavor and highly sensitive qualities of milk and cream, and milk products like butter, cheese, ice cream and powdered milk.

The delicious taste of your dairy products and the assurance of their purity is due to the dairyman's extreme care and scientific methods and the use of Stainless Steel equipment.

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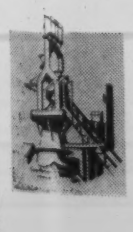
For the product you make today and the product you plan for tomorrow specify McLouth high quality sheet and strip Stainless Steel



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If you now use spray guns to coat your metal products and parts, put them permanently away and switch to time- and money-saving Certified*Enamelstrip Pre-Coated Metal Coil! Whatever you make: battery caps or home air conditioners, buttons or business machines, film cans or curtain rods, toys or baseboard heating panels – we will show you how to make it better with Enamelstrip! Enamelstrip will cut your cost, speed your production, reduce labor man-hours and cut storage space needs. NO WASTE from cutting and trimming means better profits. NO MORE PAINT SHOP FIRE HAZARD, NO MORE COSTLY INSURANCE! Enamelstrip is available in your choice of colors on one or both sides – or one color one side and a different color on the reverse side; REVERSE THE COIL, AND HAVE ANOTHER INVENTORY. Write department NB today.

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In organic coatings, Enamelstrip is available in alkyds, vinyls, epoxies, phenolics, oleoresinous and other types of enamels and lacquers. Base metals include cold rolled steel, tin mill black plate, electrolytic tin plate, electro galvanized steel, aluminum, brass, copper, and zinc.

*Tested and certified by U.S. Testing Co.

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divulge, but rather with the end properties of the cured part.

Rubber is complex

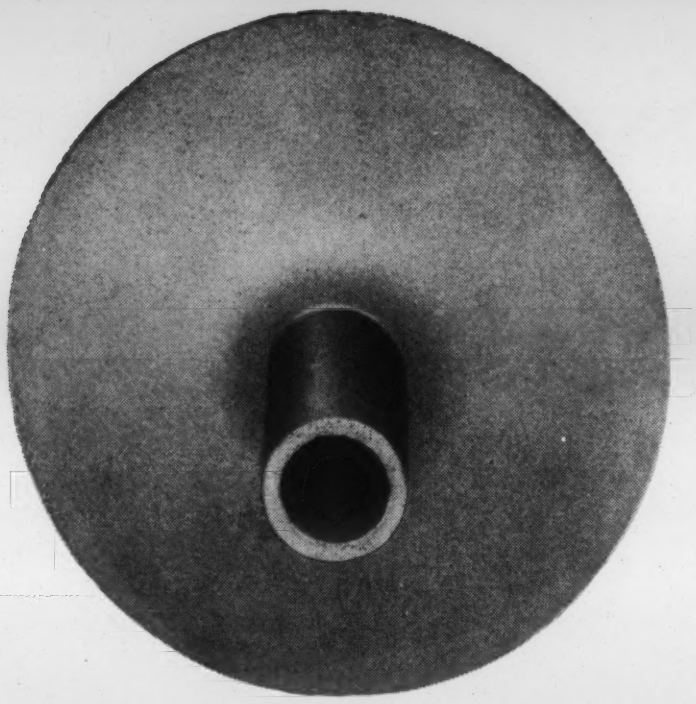
Proprietary considerations are not the only reasons why specifying rubber by composition is usually unsatisfactory. Rubber products are made of complex compounds. Although the base polymer is the main determinant of such things as oil or chemical resistance, heat build-up, permanent set and the rate at which physical properties change with temperature, nevertheless it is only 25 to 70% of the compound. The remainder consists of accelerators, vulcanizing agents, antioxidants, fillers and plasticizers. In addition, a rubber compound can vary in physical properties like any other material. It is possible to give a rubber compound formula to six different manufacturers and secure products from the same mold which have six different sets of physical properties.

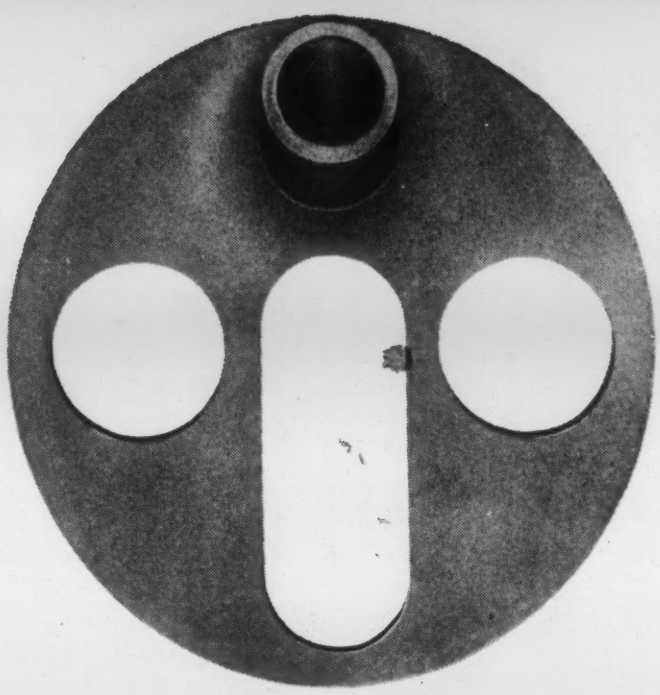
Fortunately, ASTM specifications are available on ozone resistance, abrasion resistance, tear resistance, cut growth, tensile strength, elongation, hardness, electrical properties and other properties. Other rubber specifications include a series for determining rubber properties and a general specification, D 735-55T, on rubber and synthetic rubber compounds for automotive applications.

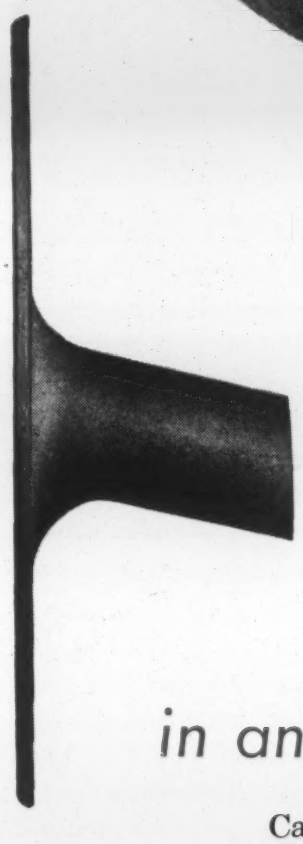
What specs mean

For example, R620 designates a natural rubber compound of 60 durometer, 2,000 psi tensile and 400% elongation that does not decrease more than 25% in tensile and elongation after aging for 70 hr at 158 F. Suffixes can be added to specify additional properties such as load-deflection, tear resistance, low temperature flexibility, adhesion to metal and nonstaining characteristics; e.g., suffix B for compression set.

Similarly, a neoprene compound, designated SC620, indicates to the







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Can your product benefit from the important features shown in these Crucible Accumet® precision investment stainless castings? They are tube supports for jet aircraft engine assemblies, but the characteristics they illustrate are just as vital to thousands of other applications.

THIN WALLS — Accurately produced by the Accumet casting process, they are impossible to make in sand or shell mold castings — very difficult to forge.

BLIND HOLES — like this one, are impossible to forge, expensive to machine, and very difficult to sand cast . . . but they can be held to close tolerances by Accumet casting.

CORING — Deep or intricate cores — prohibitively costly to machine — can be economically produced by the Accumet process.

ODD SHAPED PARTS — difficult to chuck and machine, are economical when they're Accumet castings.

Next time your designs call for parts with intricate shapes . . . close tolerances . . . fine finish . . . high quality and uniformity, make them Crucible Accumet castings. They are available in any grade of steel or high alloy your product calls for. Let a Crucible engineer give you all the facts about how Accumet castings can save you time and money. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

Write for a **free** copy of the informative folder "Accumet Castings".

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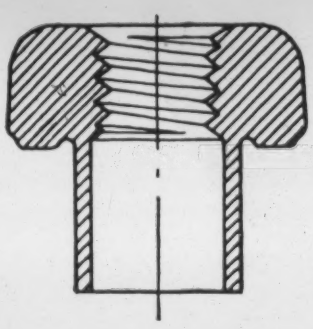
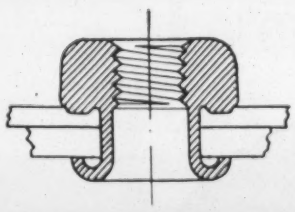
NEW Tubular's 2 in 1 fastener



PERMA-NUT®

1. makes a *PERMANENT* rivet fastening with threaded *NUT* head

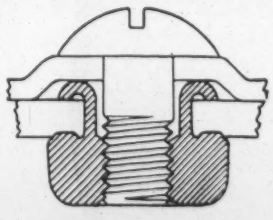
2. provides convenient and fast *ASSEMBLY* or *DISASSEMBLY* of parts



PERMA-NUT after Setting with a Roll Clinch

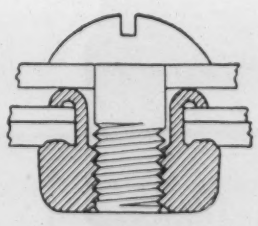
Here's a revolutionary new type of fastener combining the permanence of a rivet and the assembly and disassembly features of a nut. Fastened automatically with *Tubular's* Automatic Riveting Machines, PERMA-NUTS will save assembly hours and labor — and at the same time give you these additional advantages:

- function as a rivet, permanently fastening two or more parts, making nut available to fasten other parts.
- permanently clinch nut to a single part for fastening of other parts.
- prevent loss of nut.
- allow installation of nuts in hard-to-reach locations or which become "blind" after assembly.
- eliminate drilling and tapping certain holes.
- prevent nut from turning — sixteen radial serrations bite into part when PERMA-NUT is clinched.
- allow you to realize savings in cost over more expensive threaded fasteners.
- will not pull out of rivet clinch when properly set — clinch is stronger than the threads of nut head.



PERMA-NUT Flush Mounts 2 Parts

Available in steel, brass or 5056 aluminum, PERMA-NUTS are supplied in standard thread sizes of: 3-48NC-2, 4-40NC-2, 5-40NC-2, 6-32NC-2, 8-32NC-2, 10-24NC-2 and 10-32NF-2. PERMA-NUTS of special sizes or with various kinds of plating can be supplied to meet special applications.



PERMA-NUT Fastens 2 Parts, Uses Clinch for Spacer, Fastens 3rd Part into Nut

Send for sample, design data and specifications of standard PERMA-NUTS. If you have an immediate fastening problem, call your nearest *Tubular* Branch Office. PERMA-NUTS are now being used for vacuum cleaner shields, on protective guards, electronic chassis and similar applications. Where fastening is required PLUS assembly and disassembly features, PERMA-NUTS can be the answer to your problem.

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What's new IN MATERIALS

potential buyer that the rubber has a hardness of 60, a tensile of 2,000 psi and a swell in ASTM No. 3 oil of 40 to 110%. Changing to specification SB620 means changing to an acrylonitrile compound, such as Hycar or Paracril, with the same tensile and elongation properties but with a swell in No. 3 oil reduced to 0 to 50%.

Why specs are needed

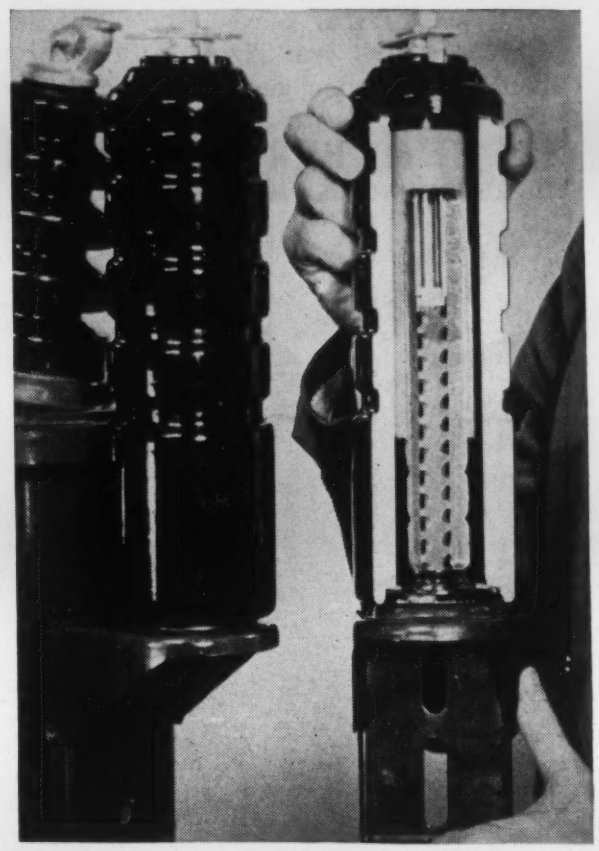
Mr. Stringfield cited several cases to show what can happen when a rubber compound is improperly specified. A user of calendered rubber sheeting who was purchasing by the pound without a weight specification found that the specific gravity of the stock had been gradually increased by his supplier from 1.14 to 1.42, giving correspondingly fewer pieces per pound. A manufacturer of ladies underwear suddenly began to receive complaints that dresses used over his shoulder pads turned a bright yellow and did not become white with washing or dry cleaning; the rubber supplier had changed antioxidants without considering the effect of the change in color.

Mr. Stringfield also had some suggestions on cost. He pointed out that the cost of a molded rubber part is based on four things: 1) cost of materials; 2) press charge or cost for vulcanization; 3) labor costs for such items as trimming, dry ice tumbling, etc.; and 4) amortization of molds and tooling. Since materials cost is only a small percentage of the cost of most rubber products, it is possible to obtain good rubber compounds at only a small premium over a cheap and possibly unsatisfactory compound. He also suggested that the prospective purchaser check the specific gravity of different compounds against their other physical properties and select the lightest one feasible, since shipping charges are frequently an important cost item.

(more What's New on p 186)

THE NATIONAL SCENE

NATIONAL HELPS TAME LIGHTNING BOLTS to keep electrical equipment in service. Lightning shattered this line pole but couldn't knock out the Westinghouse distribution transformer. Reason: a "safety valve" of National Vulcanized Fibre. A diffuser assembly of this tough insulating material smothered the explosive electric arc and kept the transformer on the job—without a moment's interruption in power supply.



NATIONAL OFFERS INDUSTRY'S BROADEST LINE of basic materials—more than 100 different grades and combinations. Heart of this lightning arrestor, for example, is hard, dense, dielectric *bone fibre*—specially selected to absorb tremendous surges of voltage—tame and quench destructive arcs—dissipate intense heat and dangerous gases harmlessly. Name the combination of properties you need—electrical, mechanical, chemical. You'll find the "one best material" at National.

NATIONAL FABRICATES PRECISION COMPONENTS for hundreds of electrical, electronic, mechanical and chemical applications. Case in point: this sleeve and spiral insert were machined to Westinghouse design specifications. Parts like these exemplify National's fabricating skill. From the simplest punching to the most complex forming or screw machine operation, you get the same result: *100% usable parts.*

NATIONAL CAN HELP YOU reduce unit product cost or improve product performance at no added cost. Here's why: You can select the "one best material" from over 100 grades of PHENOLITE®, Vulcanized Fibre and NATIONAL Nylon—*without compromise in properties or cost.* You can simplify production and purchasing with the timed delivery of 100% usable parts—*from a single reliable source.* You gain competitively with National's new materials and grades *—the direct results of programmed materials-research.*

You benefit by calling National first. Check SWEET'S PD FILE 2b/Na, *the Telephone Directory yellow pages, or write Wilmington 99, Delaware, Dept. K.*

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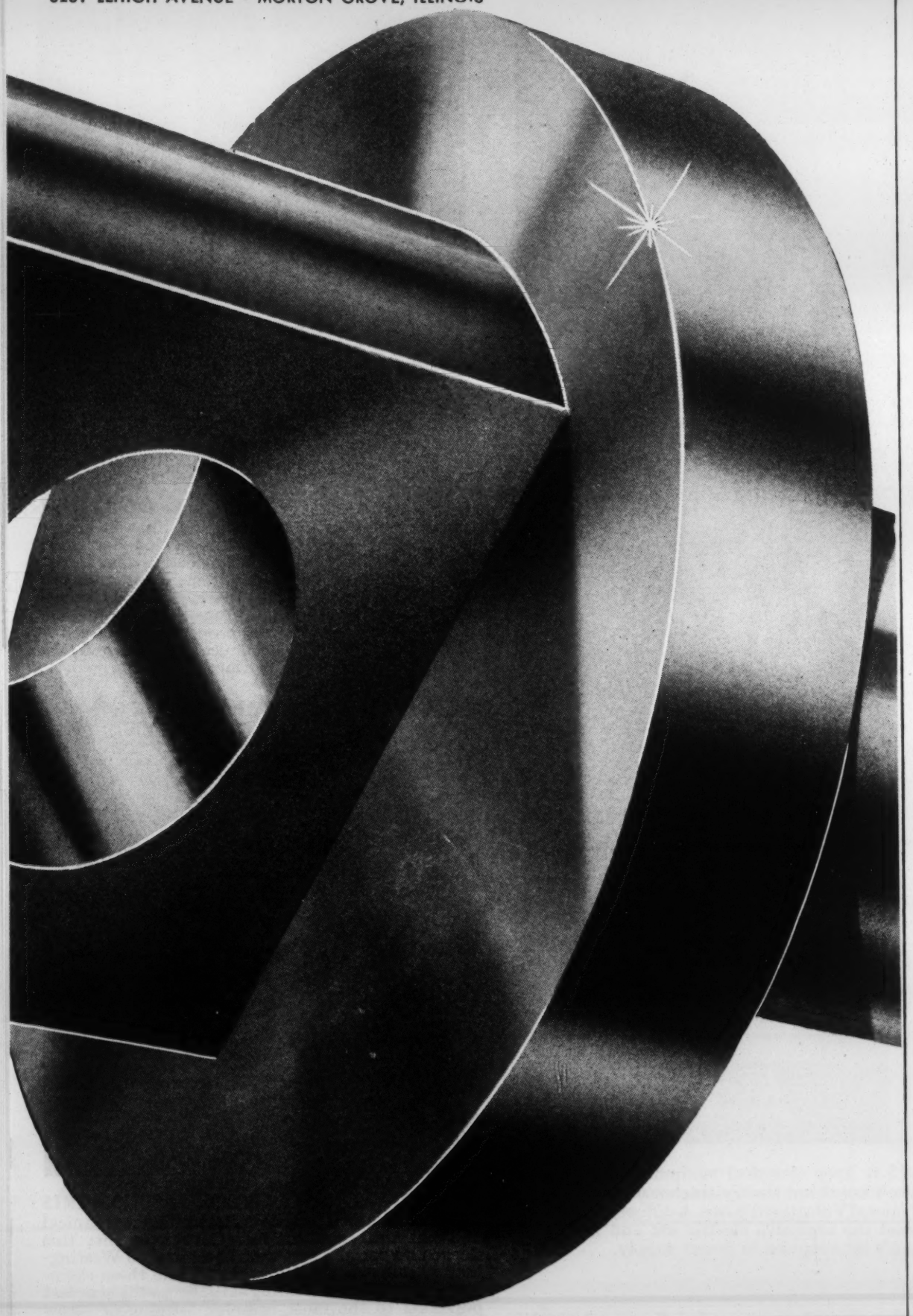
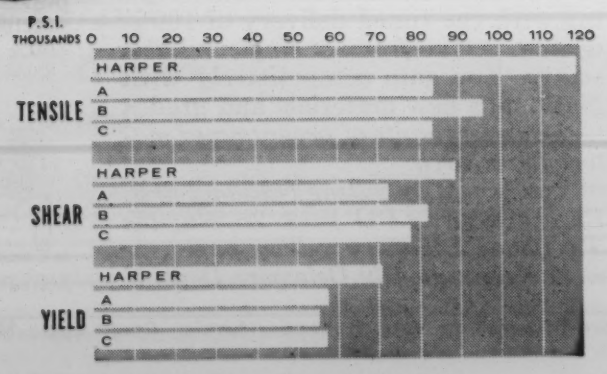


Laboratory tests prove greater strength of Harper stainless steel machine bolts

Independent laboratory tests* on stainless steel machine bolts produced by The H. M. Harper Company and three other leading producers of fastenings, prove Harper superiority in Yield, Tensile, and Shear Strength. Chart shows the actual results of these tests . . . irrefutable proof of Harper superiority! For complete details request Form No. 126.
*By R. W. Hunt Laboratories



For more information, turn to Reader Service Card, Circle No. 405

IN MATERIALS

Epoxy-Base Coatings

1. Epoxy base paint

An epoxy base paint called Metaz, claimed to withstand acids, alkalies, alcohol, grease, oil and mildew, has been developed by *Sealube Co.*, Wakefield, Mass. The paint forms a tough, firmly adherent, low friction, gloss coating on all metals, wood, wallboard, plaster and masonry surfaces. It is available in a variety of colors.

2. Epoxy-tar coatings

A line of five epoxy-tar coatings with solid contents ranging from 85 to 90% has been announced by *Carboline Co.*, 331 Thornton Ave., St. Louis 19, Mo. Each coating in this so-called Carbonmastic series is intended for specific conditions.

The coatings show good resistance to water, high humidity, brine, refinery products, ultraviolet light, hydrogen sulfide gas, ammonia, acids, salts and alkalies. A two coat system with total thickness of 20 mils is generally recommended. Cost of applying the coatings is claimed to be less than 1¢ per sq ft.

New Bolting Steel for High Temperatures

The most widely used bolting steels for temperatures up to approximately 1000 F are the chromium - molybdenum - vanadium grades. For applications at higher temperatures it is necessary to use more creep resistant materials. According to a report by M. G. Gemmill and J. D. Murray in the Dec '55 issue of *Engineering*, the useful temperature range of these steels can be extended by increasing the molybdenum and vanadium contents.

The authors made a systematic study of the influence of carbon, molybdenum and vanadium upon the properties of 24 experimental 1% chromium steels, followed by more extensive tests upon three

commercial casts of a composition based on this experimental work. As a result, they found that changing from a 1 chromium-0.5 molybdenum-0.25% vanadium steel to a 1 chromium-1 molybdenum-0.75% vanadium steel produced a material that possesses adequate creep resistance for service as a bolt steel at 1050 F.

Pipe Insulation Withstands 1800 F

A heat insulation product, called Kaylo-20, that is said to withstand temperatures of 1800 F has been developed by *Owens-Illinois Glass Co.*, Toledo, Ohio. The hydrous calcium silicate product available in pipe and block, is produced in a fingernail pink color to distinguish it from the company's standard Kaylo which is effective up to 1200 F.

The insulation is used primarily as a covering for pipes and vessels and is said to have the unique advantage of expanding slightly up to 1100 F. When the insulation is completely immersed in a test furnace at 1800 F, its shrinkage is limited to about 1½%. The insulation, whose properties approach those of refractories, was developed to meet the requirements of the chemical, power and petroleum industries where increasingly higher temperatures are being encountered.

In addition to its heat resistance properties, the insulation combines light weight (11 lb per cu ft) with enduring strength (150 psi under compression) and is insoluble in water. When dry, it regains its original thermal efficiency and strength without shrinking or warping. It is easily cut and sawed, making it adaptable to unconventional surfaces.

It is produced in thicknesses and diameters for pipe sizes from ½ to 39 in. Outside diameters of the insulation correspond to those of standard pipes, assuring proper

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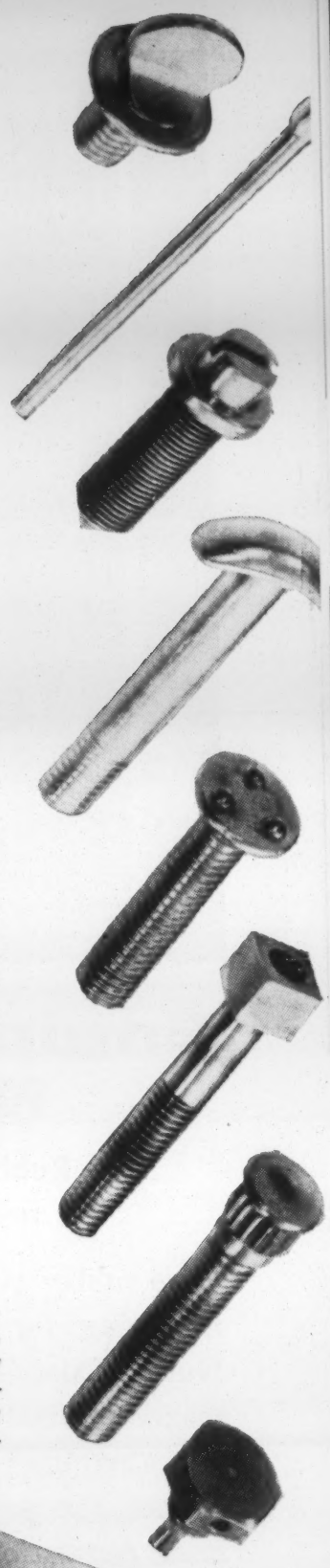

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Only Harper, with its vast experience in corrosion-resistant fastenings, could develop Flo-Form—the copyrighted name for an exclusive process that turns out problem specials *better, faster,* and at *lower cost!* Call your nearby Harper Branch and outline your *"special problem"* to a Harper Application Engineer. See how quickly the team of Harper engineering, metallurgical, and tooling specialists speeds the right answer to you. See how Harper Flo-Form produces a cleaner, stronger, better special . . . faster . . . at lower cost! Draw upon our thirty-three years of know-how. Send your problem to The H. M. Harper Company, *today!*

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Meet Harper Application Engineer, JAMES TURNBULL

Mr. Turnbull is typical of Harper Application Engineering Service. From the Harper Branch in New York City, he works with industry throughout Metropolitan New York. Important service by Mr. Turnbull includes daily solutions to special problems, through hand-in-glove work with Harper users.

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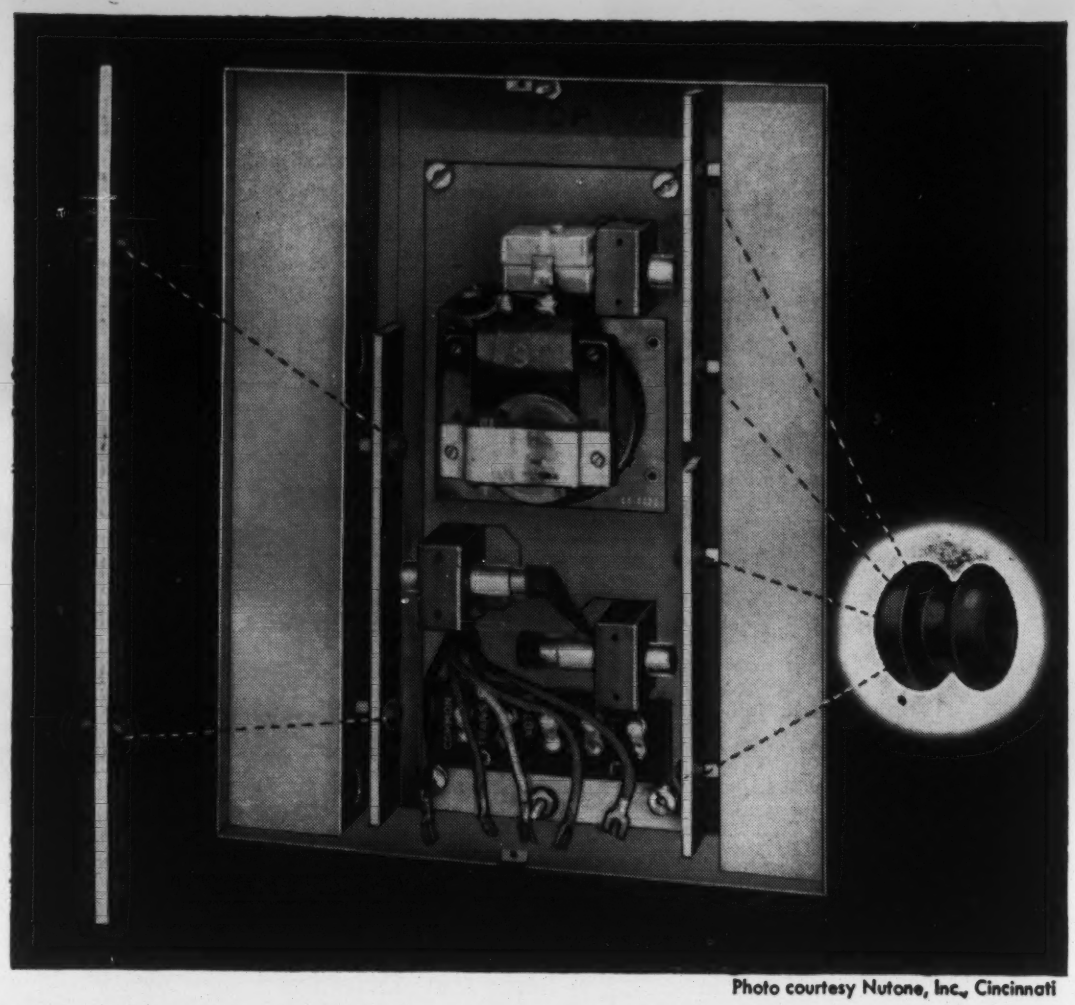

Photo courtesy Nutone, Inc., Cincinnati

Engineers Develop New Use for Rubber

Rubber, normally used to *reduce* vibration, now can be made to *increase* vibration

Here rubber grommets serve as mountings for the tone bars in Nutone Door Chimes. To obtain maximum tone quality and resonance required of these musical chimes, the grommets must vibrate compatibly with the tone bars . . . a truly *unusual assignment* for rubber.

Only by skillful compounding can rubber be diverted from its normal dampening characteristic and be given this vibrant quality. The slightest deadening effect would destroy the rich tones and kill the tone hang.

The successful development of this lively, age-resistant rubber stock typifies the complete engineering and laboratory—as well as manufacturing—skill available at Continental. Whenever you need "engineered rubber parts" — molded or extruded, natural or synthetic—call Continental, Specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

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fit and permitting nesting when necessary. The block is made 36 in long, in standard widths up to 18 in., and in thicknesses up to 3 in.

The material is recommended for use on autoclaves, boilers, breechings, condensers, dryers, evaporators, furnaces, heat exchangers, hot air ducts, kilns, glass annealing furnaces, locomotives, steam lines, tanks, turbines and vessels.

Protective Coatings Made from Sea Water

by John Starr

Two of the oldest and most expensive enemies of seagoing vessels, corrosion and barnacles, may be eliminated with a new electronic finishing process now being developed by Henry T. Burkey of Los Angeles.

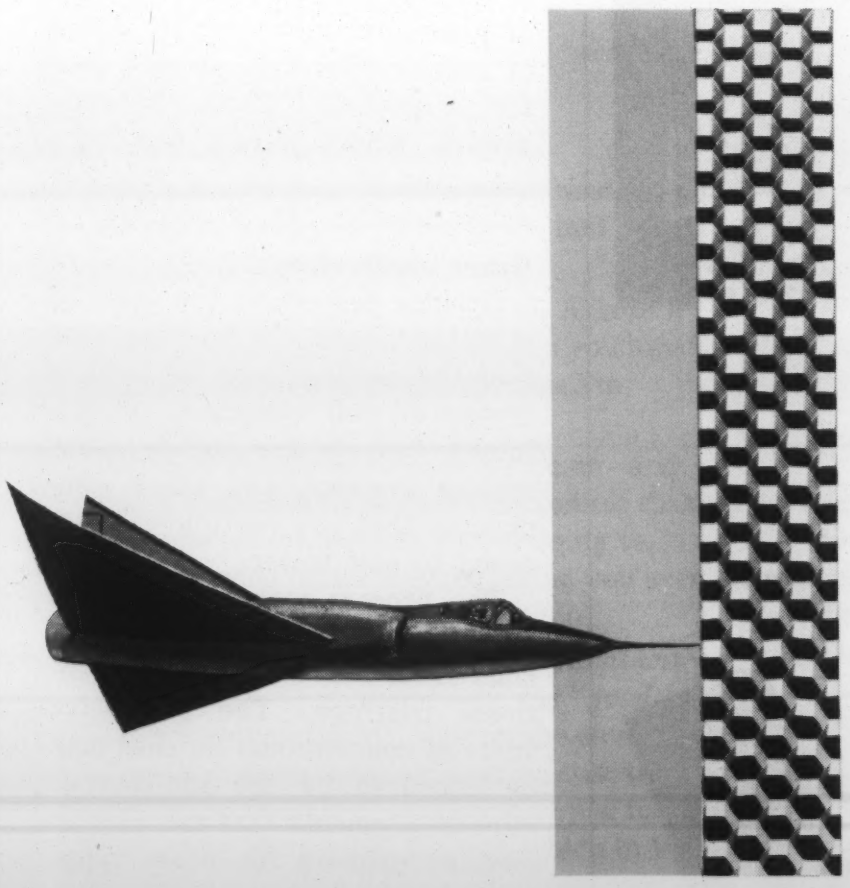
The process consists of using high voltage, low frequency current to ionize or polarize particles naturally suspended in brine water. The particles are electromagnetically attracted to and deposited on a grounded metal surface, such as the hull of a ship.

The coating development is the indirect result of the inventor's work with "fish fences" — electronic devices that are used to keep fish from entering municipal reservoirs and hydroelectric water lines where the presence of fish might cause serious damage to turbines and other equipment. Mr. Burkey began his present work after he noticed that the fish fences, charged with high voltage pulses, were impervious to salt water corrosion.

How coatings are applied

The equipment used in the coating process is designed so that it delivers relatively high voltage pulses through a Monel pipe electrode. The electrode is submerged in brine water several feet away

ICARUS never had a chance!



A "thermal barrier" ended Icarus' fabled flight when his beeswax and feather wings melted in the Mediterranean sun.

The men who are designing and building planes to fly at tomorrow's speeds are also facing thermal barriers and the problems of finding structural materials capable of withstanding the inferno of air friction.

We at Hexcel Products Inc., are developing new honeycomb materials with future speeds and temperatures in mind. At present new materials and new methods are being tested and re-tested in our laboratories. The goal—to produce Hexcel structural honeycomb sandwich cores with far greater resistance to extreme temperatures and even better insulating properties.

For further information regarding Hexcel Honeycomb core materials write or wire Hexcel Products Inc., 951-61st Street, Oakland 8, California. Branch offices are located at: 1025 W. Arbor Vitae Street, Inglewood 1, California; Havre de Grace, Maryland; and 3309 Winthrop Avenue, Fort Worth, Texas.

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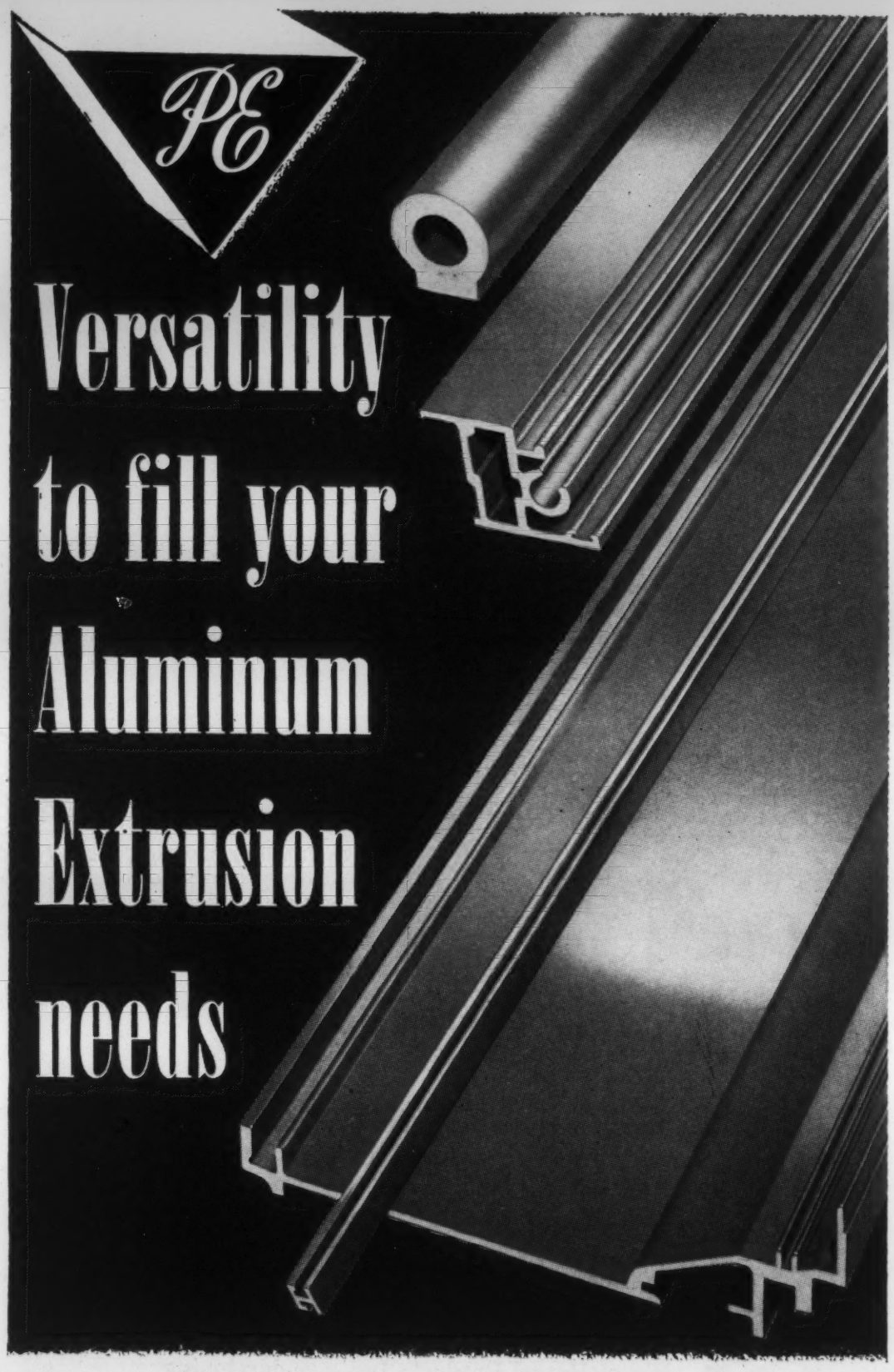

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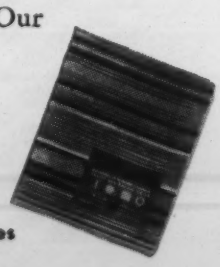

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from the surface to be coated. Power consumed in the operation is said to be less than that required by a 100-w light bulb. (The equipment has not been described in detail, presumably for defense reasons.) After a 48-hr period, a uniform, grayish coating, comprised of both metallic and nonmetallic particles, is deposited on the metal surface. The deposited coating has a maximum depth of less than 0.005 in.—the thickness of a standard electroplated coating.

The ultra-thin coating is said to have excellent abrasion resistance and can be replaced at frequent intervals. It is claimed that the coating is cheaper to use than materials presently being used for hull maintenance of seagoing vessels. The fact that the coating will not materially add to the weight of a ship may also be advantageous.

In addition to its corrosion resistance and low cost, the coating is claimed to prevent the growth of algae and other minute forms of marine life that provide food for barnacles. Thus, barnacle growth, whose weight can halve the speed of a seagoing vessel in a few months, can be stopped.

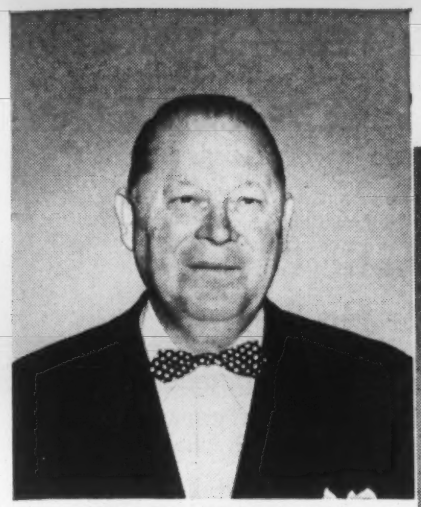
Other applications

Besides protecting the hulls of seagoing vessels, the inventor says that the coatings may be used to protect oil well equipment, pilings, intake tunnels for utility plant cooling systems, and other components that are continuously exposed to salt water.

The process may also be used to extract chemically pure materials from sea water for conventional coatings. The decorative value of conventional finishes may be improved by the addition of mineral pigments that can also be used as primers for other types of coatings.

Tests are currently being conducted on steel plates measuring 12 x 15 x ⅛ in. According to the inventor, large surfaces made of different metals could be satisfac-

"To Err is Human..."



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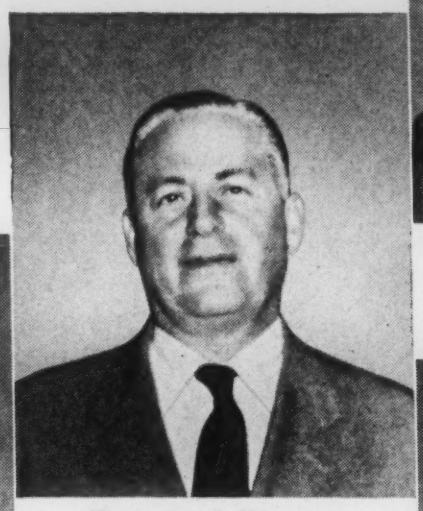
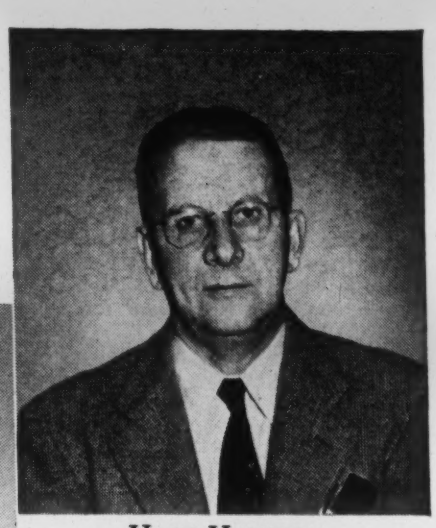
President
43 years

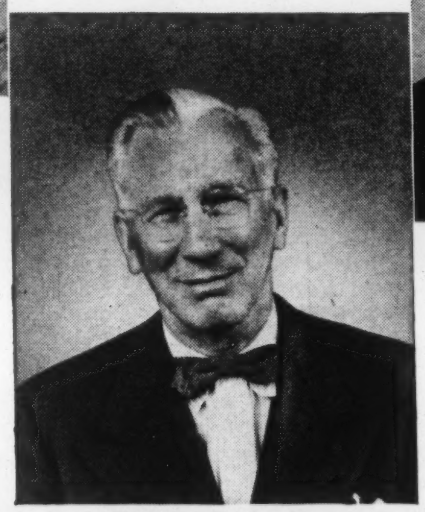
LEWIS HELD
Vice President
21 years



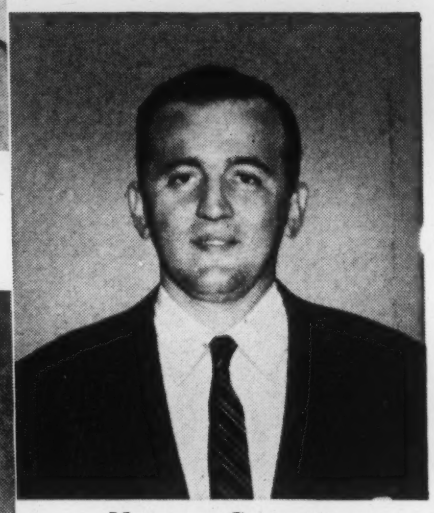
THOMAS J. WALKER
Controller & Secretary
21 years



HANS HANSON
Die Room Supervisor
40 years



GEORGE NEWBERG
Tool Room Supervisor
32 years



VINCENT SARACCO
Eng. Asst. to V. P.
15 years

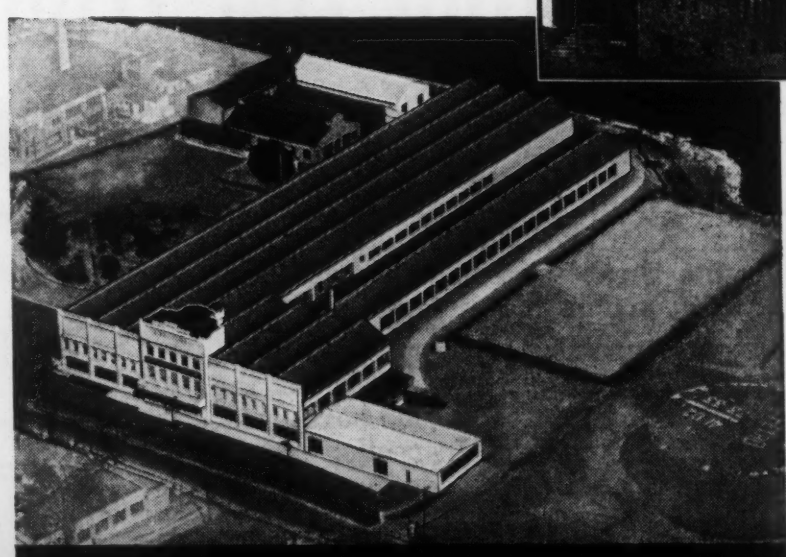
— but when we've made mistakes at Mt. Vernon, it's the customer who benefits

If there lives a man who has never made a mistake—it's because he has never had the courage to try anything new.

The 6 men pictured here are the men to whom you entrust your work when you hire Mt. Vernon to do it. The total of their experience in die casting adds up to 172 years.

Each of them is exceedingly human—and each of them would be the first to admit that he has made some mistakes. But in doing so, he has learned better ways of giving you ever finer die casting, at ever lower cost to you.

It is these men's perpetual discontent with doing things the accepted way, the "good-enough" way, that has gained for Mt. Vernon the enviable name that we have today. It is because they *have* made some mistakes—and because *you* have profited by them—that the firm which in 1905 started in a modest 2 story building (inset) has grown into this complete and completely modern die casting plant occupying 200,000 square feet.



MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

For more information, turn to Reader Service Card, Circle No. 431

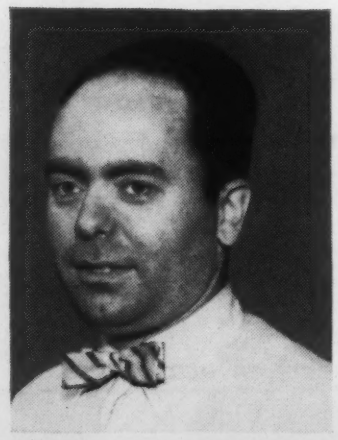
Solving problems with VULCAN Tool Steels:

Production run tripled

Until recently, a run of 200,000 switch boxes on a double-acting draw press was an accepted standard at Steel City Electric Company, Pittsburgh. The compound die used in this single-stroke blanking and drawing application is subjected to severe abrasion. The boxes come off the press hot.

Under pressure for greater production, Vulcan Alidie tool steel was used for the complete tooling set-up. 688,000 boxes were produced in one tool run. Inspection proved that the run could have gone even longer.

Is there room for this kind of improvement in your production schedule? Talk to your Vulcan representative—your specialist in *forged* tool steels. *Vulcan Crucible Steel Division, H. K. Porter Company, Inc. Aliquippa, Pa. Offices and warehouses in principal cities.*



Jesse Casasanta, tool and die superviser, Steel City Electric Company, calls the performance of Vulcan Alidie Tool Steel in this test "a near miracle."

HKP VULCAN CRUCIBLE STEEL DIVISION
H. K. PORTER COMPANY, INC.

For more information, turn to Reader Service Card, Circle No. 458

torily coated with existing test facilities. However, more elaborate equipment would probably be required for such operations as "pushbutton refinishing" of the hull of an aircraft carrier

Synthetic Ceramic Needs No Firing

With the development of a new synthetic porcelain ceramic, it is now possible to make ceramic-like products by a cold set process without kiln firing.

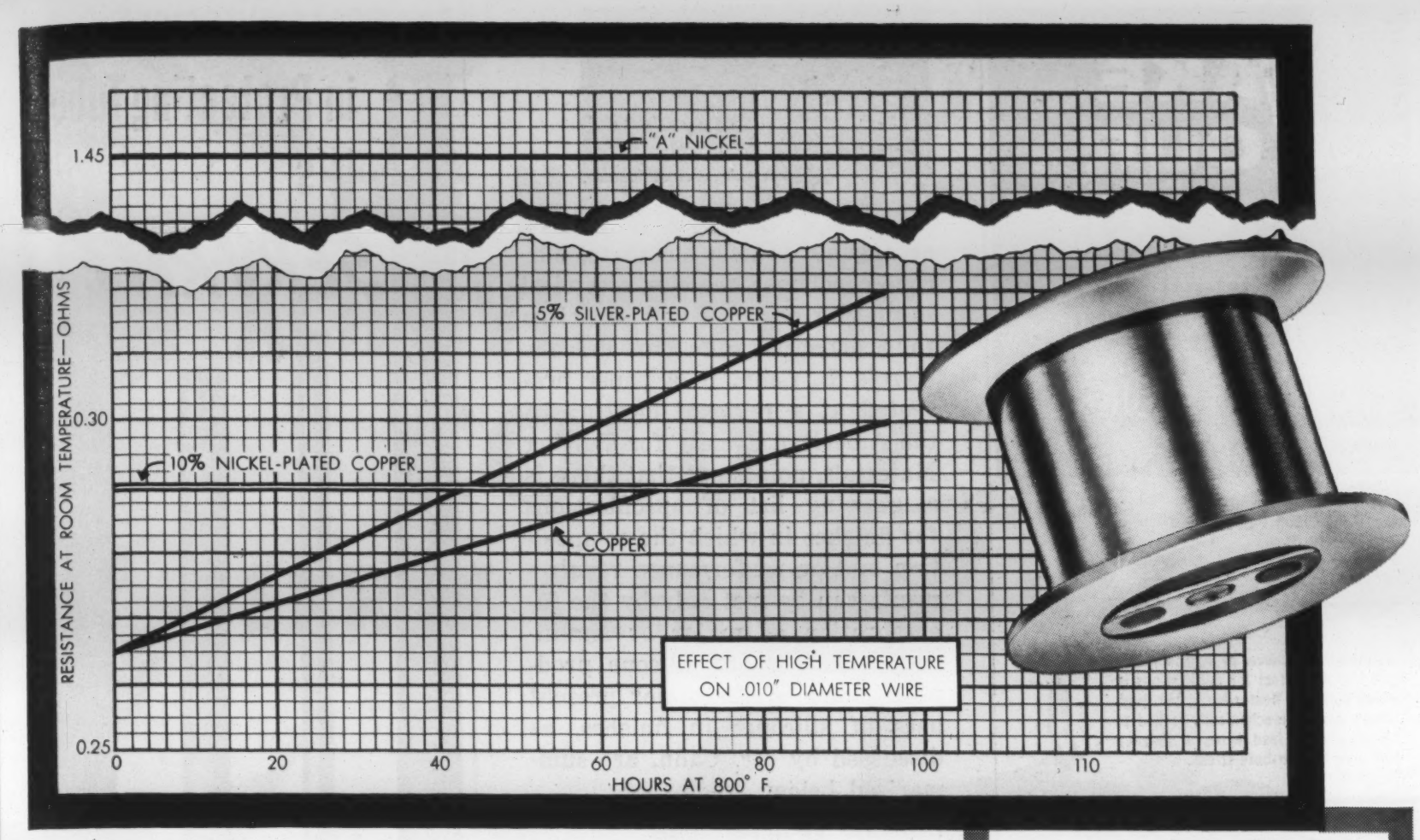
Developed by *Sauereisen Cements Co.*, Pittsburgh 15, Pa., the synthetic ceramic material, known as Sauereisen Pour-Lay Cement No. 54, is supplied in two parts—a dry filler and a liquid binder—which are mixed together as the cement is used. An internal chemical setting action hardens the material at room temperatures, initial set requiring approximately 30 min and final 6 to 12 hr.

The material may be impregnated with varnish or wax to make it nonporous. It is said to be water, oil, solvent and acid resistant (except to hydrofluoric), and is also said to be able to withstand temperatures to 2000 F. Mechanical strength of the material is reported to be about the same as that of concrete.

The material may be cast into special shapes in linoleum, wood, rubber and metal molds where the quantity does not justify more expensive molds.

Use of Silicones in Protective Coatings

Silicone products have been commercially available for about ten years. During that time the uses of silicones have mushroomed. In the protective coatings field, for example, silicone resins were first used as the sole vehicle for high temperature resistant paints. Now they are also used



Nickel-plated copper...

for high conductivity at elevated temperatures

SYLVANIA's Nickel-plated copper wire combines the conductivity of copper with the corrosion-resistant properties of nickel for applications involving temperatures ranging from 350° Fahrenheit to 700° Fahrenheit.

Equal lengths of Nickel-plated copper and three other wires were heated in air at 800° Fahrenheit for an extended period to determine the effect of heat on conductivity.

Nickel-plated copper, more than any of the other wires except for pure nickel, holds its original low resistance. It's this feature which, in many cases, has made Nickel-plated copper more desirable than costlier wires used where conductivity must remain constant under high temperature environment.

Nickel-plated copper wire can be supplied in a full range of diameters from .250″ to .005″.

Sylvania is the only major wire supplier with complete facilities for plating and cladding wire. This makes it possible to provide you with an experienced, objective recommendation as to whether a plated or a clad wire is best suited for your application.

In addition, Sylvania's Parts Division offers you complete 4-way service including custom molded plastic parts, small metal parts ranging from wire forms to deep drawn parts, and special electronic components. Write for the "Portfolio of 4-way Service" and the new technical bulletin on Nickel-Plated Copper Wire.

SYLVANIA PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS

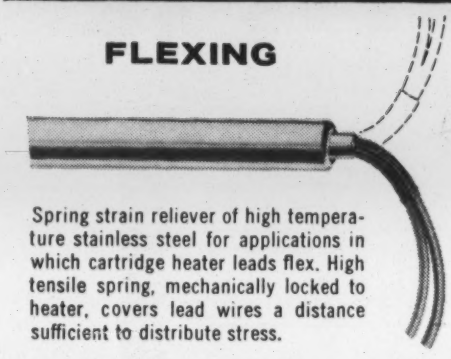
4-way service from one source

For more information, turn to Reader Service Card, Circle No. 414

TAKE YOUR PICK!

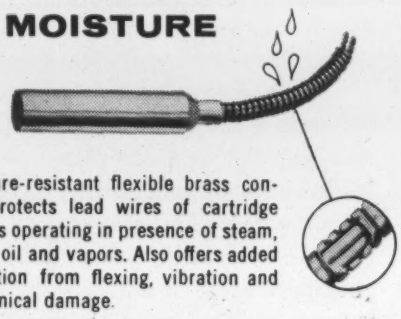
Special Chromalox features solve 3 spot heating problems

FLEXING



Spring strain reliever of high temperature stainless steel for applications in which cartridge heater leads flex. High tensile spring, mechanically locked to heater, covers lead wires a distance sufficient to distribute stress.

MOISTURE



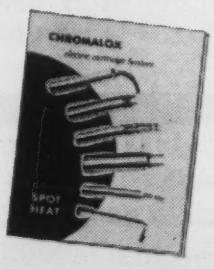
Moisture-resistant flexible brass conduit protects lead wires of cartridge heaters operating in presence of steam, water, oil and vapors. Also offers added protection from flexing, vibration and mechanical damage.

ABRASION

Flexible brass conduit protects cartridge heater lead wires against abrasion from other moving parts and from accidental mechanical damage. Safety factor where lead wires are exposed to machine operator.

FREE BULLETIN!

CHROMALOX ELECTRIC CARTRIDGE HEATERS



Get the full story. Call your Chromalox Representative or write today for Bulletin 850.

C-2101

Edwin L. Wiegand Company

7523 Thomas Boulevard • Pittsburgh 8, Pa.

For more information, Circle No. 489

What's new IN MATERIALS

as organic vehicle modifiers, silicone copolymer vehicles, electrical insulating coatings and additives for correction of film defects. Harold L. Cahn, in a paper presented at a regional meeting of the American Society for Testing Materials, points out that there is a growing list of specifications for finishes in which the composition and/or performance requirements can be met only by the incorporation of major or significant quantities of silicone products. Some of the major present uses of silicones in finishes, as discussed by Mr. Cahn, are summarized below.

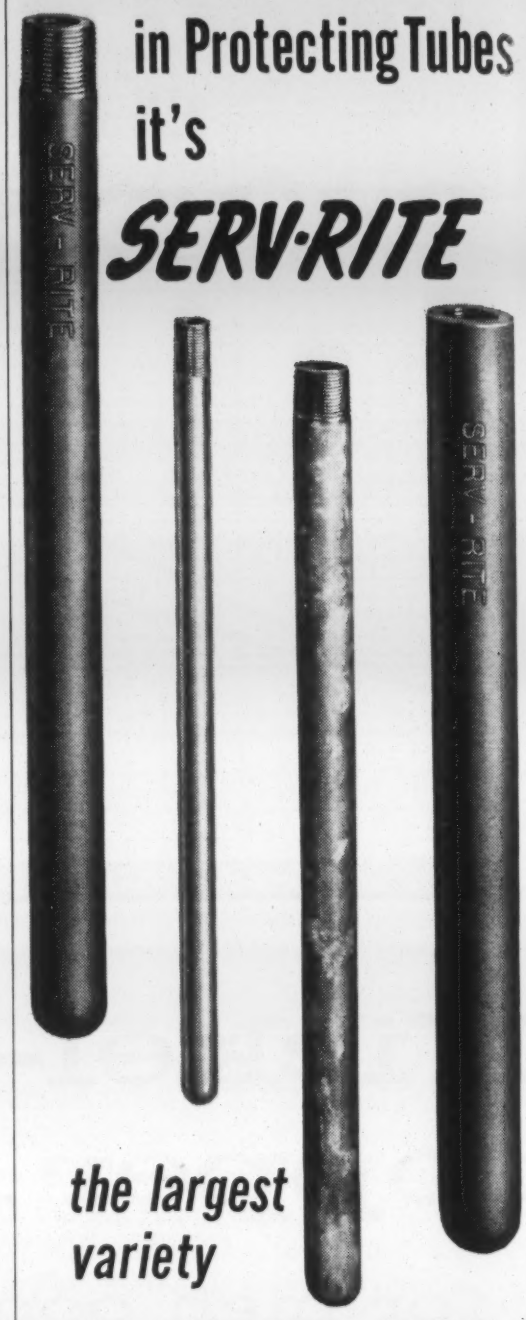
Silicone vehicles

The classic example of the use of silicone resins in protective coatings is high temperature aluminum paint, the vehicle being 100% silicone resin. A paint based on 100% silicone resin vehicle finds its greatest use at temperatures around 500 F. It could also be used at 1000 F or higher. The solids of a silicone resin are nonvolatile at all ordinary temperatures, and only slightly volatile during long exposure at 500 F.

During initial heating, the organic portion of the paint volatilizes and the silicone resin sets the aluminum film in place. As the temperature rises further, the silicone resin volatilizes while the aluminum film is becoming fused to the material. Therefore, only enough silicone vehicle to accomplish this end, approximately 50%, is used.

When 100% silicone resin paints are tested they are exposed to actual service temperature conditions. Results should show no general film deterioration, and no more than slight difference in appearance from unexposed films. Most consumers of this type of paint, in both private industry and government, have established their own specifications in accordance with the intended service. Typical applications for high tem-

for any requirement in Protecting Tubes it's SERV-RITE



the largest variety

In size and length, in iron, nickel, and alloys, and in formed or precision drilled, Gordon has about the largest variety of thermocouple protecting tubes. And you get off-the-shelf delivery on most any of this great variety of "standard" tubes. Gordon also makes protecting tubes to specifications for special requirements.

Give Serv-Rite a trial on your next protecting tube requirements. You can't go wrong. Careful manufacture and rigid inspections assure satisfaction. Get full information today. Ask for Bulletin 11-13.

● Bulletin 11-13 gives general application data, specifications, and ordering information on Serv-Rite protecting tubes and protecting wells—the largest grouping in one listing.

6221

CLAUD S. GORDON CO.

Manufacturers • Engineers • Distributors

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2023 Hamilton Ave., Cleveland 14, O.

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THE NEWEST ACHIEVEMENT IN COLD SPRAY CLEANING

Jet 50

JET 50 HAS EVERYTHING IT TAKES TO SET NEW RECORDS FOR SPRAY CLEANING EFFICIENCY IN YOUR PLANT.

- A non-foaming spray cleaner that works at room temperature.
- Safe for use on all metals.
- A positive rust inhibitor.
- Moderate cost. Long life at top efficiency.
- Heavy dirt load capacity.
- Maintains pleasant odor even with heavy dirt load.
- Prevents bacterial growth. Nontoxic. Non irritating to skin.
- Can be used hot as well as cold. No disposal problem.

Remember — YOUR COST PER FINISHED ARTICLE IS THE TRUE COST OF YOUR CLEANER

LO HI pH

Let the Northwest Cleaning Specialist explain how Jet 50 can improve your production.

NORTHWEST CHEMICAL CO.

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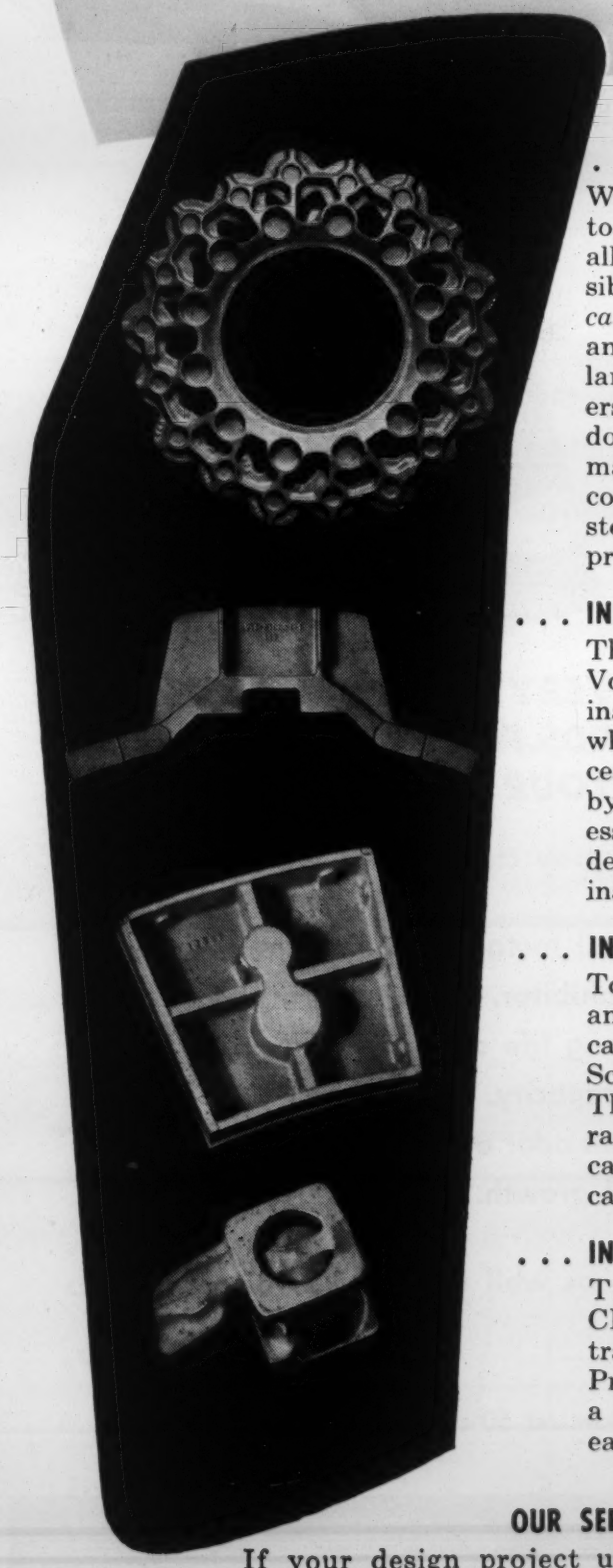
pioneers in pH cleaning control serving you since '32

For more information, turn to Reader Service Card, Circle No. 362

CERAMICAST* HAS CHANGED DESIGN CONCEPTS . . .



. . . IN AIRCRAFT BRAKE SYSTEMS

When aircraft landing speeds became too fast for braking systems of light alloys, CERAMICAST made it possible to produce backing plates in *cast steel* that will stand the stresses and high temperatures placed on the landing gear of today's super bombers and fighters when they "touch down." Backing plate designs of six major U.S. aircraft have now been converted from light alloys to the cast steel of Lebanon's CERAMICAST process.

. . . IN JET ENGINE COMPONENTS

This jet removal track for the Chance Vought F8U-1 *Crusader* was originally designed as a machined part, which made quantity production excessively expensive. Now produced by Lebanon's CERAMICAST process in cast steel, the part retains the desirable characteristics of the original, at a considerable cost saving.

. . . IN THE BOTTLING INDUSTRY

To produce the surface smoothness and close tolerances of this bottling cap guide, engineers at Pneumatic Scale Co. specified CERAMICAST. The thin metal sections and accurately recessed pockets are significant advantages of Lebanon's new casting process.

. . . IN AIRCRAFT FUEL SYSTEMS

The unique advantages of the CERAMICAST process are illustrated in this jet engine fuel valve. Practically impossible to produce as a sand casting, this component is easily adaptable to CERAMICAST.

OUR SERVICE TO YOU

If your design project utilizes cast steel in any form, CERAMICAST may provide quality and cost advantages. Let our engineers discuss the process with you and its applicability to your problems. Write for complete descriptions and applications of the CERAMICAST process.

* CERAMICAST is a registered trademark

CIRCLE L

LEBANON STEEL FOUNDRY

96 LEHMAN STREET LEBANON, PENNSYLVANIA

CARBON, LOW ALLOY AND STAINLESS STEEL CASTINGS

For more Information, turn to Reader Service Card, Circle No. 515

What's new IN MATERIALS

perature aluminum paints are boiler and exhaust stacks, mufflers, furnace and oven exteriors, high temperature processing equipment, exhaust manifolds and jet engine components.

There are several applications where white and colored silicone paints and enamels are needed, such as home incinerators and light reflectors subjected to high heat. Various colored and iridescent metallic finishes are used to provide decorative as well as protective coatings for space heaters, ovens and other appliances and structures subjected to elevated temperatures in normal service. The principal requirement of these finishes is heat resistance.

Silicone copolymers

High silicone content copolymers were developed for temperature services from 350 to 450 F. Typical applications for finishes based on high silicone copolymers are lamp shields on ranges which are exposed to fumes and steam from cooking. Resins of this type have been used in white appliance finishes and have been found to possess many desirable properties in addition to heat resistance. Hardness, mar resistance, flexibility, soap resistance, vegetable fat and fruit juice resistance have placed silicone copolymer finishes high in appliance finish ratings. They have also been found to be resistant to JP-4 jet fuel and petroleum-based aircraft hydraulic fluid.

Silicone blends

Coatings containing up to 25% of silicone solids have been found to improve the weather resistance and heat resistance of finishes compared to 100% alkyd base finishes. To illustrate the good weather resistance properties of silicones, two alkyd resin paints were prepared identically, except that in one 25% of the alkyd vehicle solids was replaced by an equivalent quantity of silicone

In Hotel Statler, New York City...

ARMCO ZINCGRIP STEEL GUARDS CONDUITS WHERE MAINTENANCE MEN CAN'T GO

Production of conduits requires severe lock seaming, but the zinc coating on Armco ZINCGRIP Steel stays tight and unbroken. That's why conduits like this one are expected to last the life of the air conditioning system—even where inaccessible to maintenance men.

Miles of conduits and ductwork are required in the modern air conditioning system that serves 2,200 rooms of the giant hotel.

Conduits for the new air conditioning system in New York City's Hotel Statler are made of Armco ZINCGRIP® Steel. According to the project engineer in charge, this is why:

"The galvanized bond of Armco ZINCGRIP Steel is completely reliable. We can lock-seam without causing damage to the coating. This means that *conduits can be placed in inaccessible parts of the building* . . . in vertical rises between floors for example, without further attention for an indefinite period. *They'll last the life of the system itself.*" And further . . .

"In those areas where conduits are exposed, their attractive appearance does not detract from the residential nature of the hotel."

20-YEAR RECORD

For more than 20 years, drawn and severely formed parts of many kinds of products have been made of Armco ZINCGRIP Steel at cost savings.

The reasons:

1. No flaking or peeling of the patented hot-dip coating.
2. Elimination of finishing after fabrication.
3. Production advantages of ZINCGRIP coils.

Many years of experience in hundreds of plants back up this fact: *Anything that can be done with sheet steel can be done with Armco* ZINCGRIP.

ARMCO STEEL CORPORATION

817 Curtis Street, Middletown, Ohio • Sheffield Steel Division • Armco Drainage & Metal Products, Inc. • The Armco International Corporation

For more information, turn to Reader Service Card, Circle No. 376

Important! Specify TEFLON® by its properties!

TEFLON *can* provide extraordinary physical, electrical, and chemical properties, but these properties *cannot* be taken for granted.

The method used to convert Teflon powder into finished rods, sheets, and tubes greatly affects the quality obtained. This quality, in turn, governs the properties of the end product.

So to *assure* performance, actually specify not only Teflon but also the important *properties* required.

Two grades of Fluoroflex®-T deliver the *optimum* properties you specify for Teflon.

(1) "Electrical grade" Fluoroflex-T is certified to conform to all important electrical and physical properties. It meets the most critical requirements.

(2) A more economical "mechanical grade" satisfies all chemical and thermal needs and offers up to 50% greater resistance to elongation under mechanical loads.

Both grades are produced under exacting quality control standards and are stress relieved to insure that machined parts are dimensionally stable.

Send for data or better still tell us what specific properties are important for your application.

® Teflon is a DuPont trademark. Fluoroflex is a Resistoflex trademark.

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For more information, turn to Reader Service Card, Circle No. 558

resin solids. After the initial bake there was practically no difference, but after an additional 24 hr at 480 F the all-alkyd paint had lost most of its film integrity while the silicone modified paint was still in good condition.

Uranium-Plastics Tape to Aid Reactor Design

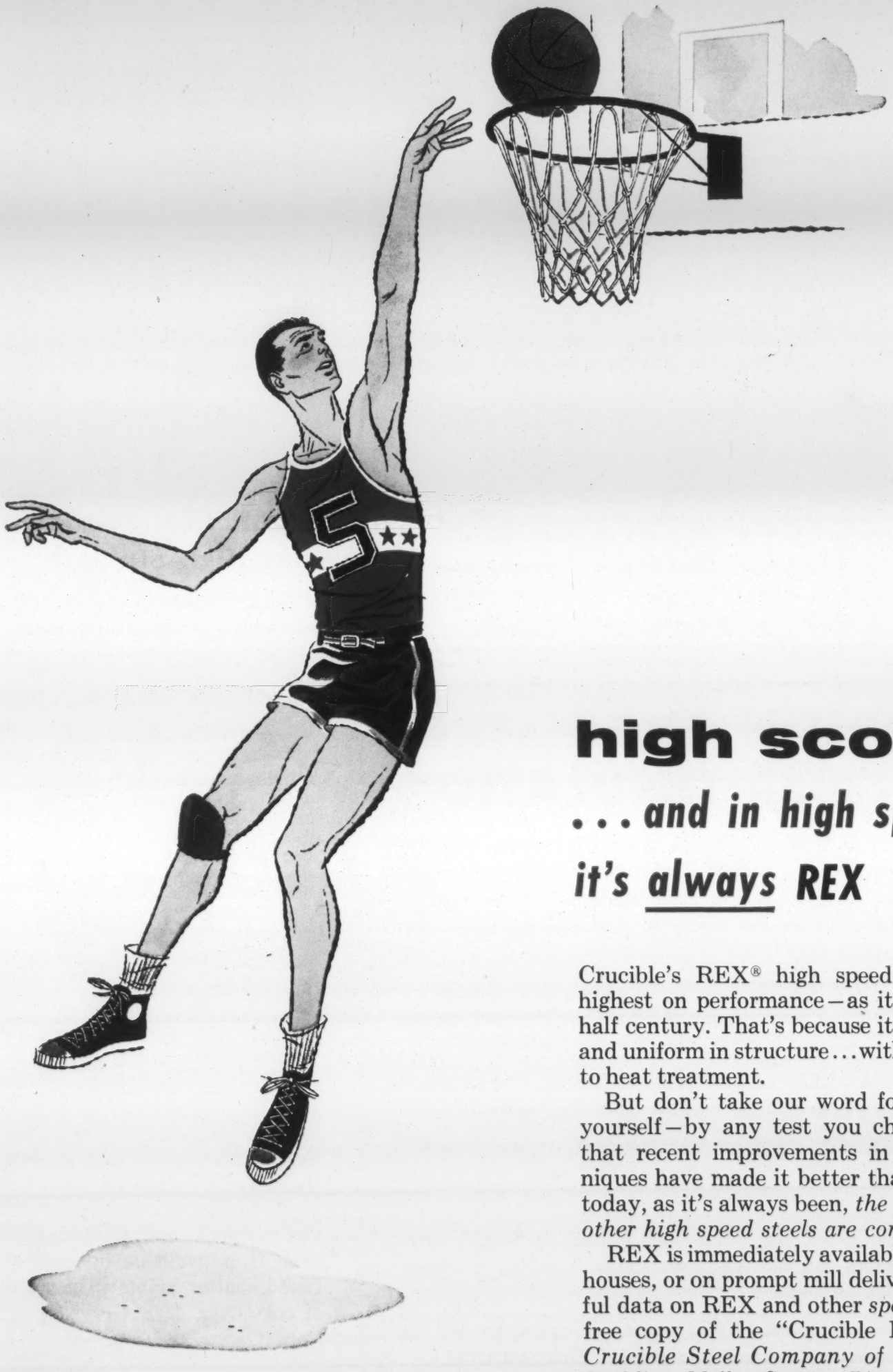
Five miles of plastics tape laden with enriched uranium will be used in experiments to help determine the reactor design for one of the nation's first nuclear power plants.

Enriched U-235 will fuel an experimental reactor Babcock & Wilcox is assembling in its Lynchburg, Va., critical experiment laboratory. Fuel elements for the test reactor will contain the uranium-diffused plastics tape sandwiched between thorium converter plates (the first time that thorium has been utilized in a reactor). In addition to providing a dispersal medium for uranium oxide, the tape will constitute an added safety device; in the event of an excessive power rise in the core, gas bubbles will form in the plastic forcing an automatic shutdown of nuclear reaction.

To produce the large amount of uranium tape the experiment requires, B&W has set up special extrusion production machinery. The equipment disperses the powdered uranium in the polyethylene tape, clads it with pure plastics tape, cools it and cuts it to the desired width.

Small Rubber Gaskets

Molded rubber gaskets having round cross sections as small as 0.020 in. have recently been produced by Minnesota Rubber & Gasket Co. Designed for sealing small units with little packing space, the gaskets are said to have dimensional tolerances as close as



high scorer

. . . and in high speed steels, it's always REX

Crucible's REX® high speed steel always scores highest on performance—as it has for more than a half century. That's because it is consistently sound and uniform in structure . . . with dependable response to heat treatment.

But don't take our word for it. Check REX for yourself—by any test you choose. You'll discover that recent improvements in manufacturing techniques have made it better than ever—why REX is today, as it's always been, *the standard by which all other high speed steels are compared!*

REX is immediately available at all Crucible warehouses, or on prompt mill delivery. For a list of helpful data on REX and other *special steels*, write for a free copy of the "Crucible Publication Catalog." *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

For more information, turn to Reader Service Card, Circle No. 470

FABRICATED PARTS

MOLDED · DIE-CUT · SHEARED · STITCHED
FACED · COATED · PLAIN · CYLINDRICAL

MAT'L:	SUPPLIER:	DATE:	DRAWN BY:
INSULATION	GUSTIN·BACON	ANYTIME	JOB

PRODUCTION ENGINEERED GLASS FIBER INSULATION

Simplify your design problems for volume produced products with this versatile line of glass fiber insulations. Gustin-Bacon manufactures glass fiber insulation for thermal insulation or sound absorption in any form you want it and ships directly from the factory to your assembly line. More specifically we can furnish you —

MOLDED INSULATION PARTS — as self supporting insulation parts or as snap-in liners for metal housings. Molded parts are the ideal material where installation of blanket insulation may not be practical.

DIE-CUT MATERIAL — plain or with facings. Cutouts and shapes to your specifications for an accurate fit in assembly line products.

CYLINDRICAL MOLDED PARTS for insulating round shapes as thermal insulation or sound absorber or as a replacement for metal. Can be used to convey air.

BLANKET ROLLS of either fine blown fibers or long textile-type fibers, in many lengths, widths and thicknesses, plain or with facings or coatings or stitched to special backing.

Let us help "engineer" insulations to fit your assembly line products. We will be glad to furnish samples and technical information. Write today to

OEM Division

GUSTIN-BACON
Manufacturing Company

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Thermal and acoustical glass fiber insulations
Pipe couplings and fittings • Molded glass fiber pipe insulation

234 WEST 10th STREET, KANSAS CITY, MISSOURI

For more information, turn to Reader Service Card, Circle No. 574

±0.001 in. The gaskets are made of both natural and synthetic rubber by an injection molding process that eliminates the flash characteristic of compression molding, thereby eliminating such secondary operations as hand or machine trimming. The injection process also permits higher densities.

Light Vinyl Fabric Has High Strength

A lightweight vinyl fabric of reversible construction that is said to have exceptionally high strength characteristics has been announced by *Jason Corp.*, 1040 Grand St., Hoboken, N. J.

Designated Fabron, the 20-oz fabric, when compared with other vinyl fabrics of the same weight is said to have 25% greater tensile strength in length and 100% greater in width. Its tear strength is 100% greater in length and 200% greater in width, and its stitch strength is 8% greater in length and 18% greater in width. The reversible construction of the vinyl fabric eliminates the need for a separate lining, and the fabric can be wiped clean on both sides.

The material is said to be scuff and stain resistant and is recommended for strollers, car beds, lunch bags, auto seat cover trim and cushions, and outdoor furniture. It is available in plaid and tweed spatter prints in a variety of colors.

Five New Adhesives Announced by 3M

During the past few months the *Adhesives and Coatings Div., Minnesota Mining & Mfg. Co.*, 411 Piquette Ave., Detroit 2, Mich., has introduced a number of new adhesives. Among them are four epoxy resin adhesives

Type 430 Bright Finish

up to 48" WIDE

BRIGHTER THAN EVER!—MicroRold stainless steel Type 430 in the NEW Bright Finish is now immediately available in sheets up to 48" wide offering new usefulness and economy in stainless fabrication. Produced with the same micro-accuracy of gauge for which MicroRold 36" is well known, Type 430 Bright up to 48" wide gives greater latitude in applications for quality stainless steel.

MicroRold 430 is also available in the regular commercial finishes and MicroRold stainless in other grades are now produced up to 48" wide. Complete details sent on request.

Washington Steel Corporation

2-F WOODLAND AVENUE WASHINGTON, PA.

For more information, turn to Reader Service Card, Circle No. 416

Now! Ajax SALT BATH FURNACES with REMOVABLE SUBMERGED ELECTRODES

What used to be a costly, time-consuming job now takes only an hour or two at the most. Labor cost is next to nothing . . . and there is little or no "down time" for the heat treating equipment because Ajax Removable Submerged Electrodes can now be changed without tearing down either the furnace wall or the pot.

Electrodes enter from over the top and slant into the salt bath. *There are no openings below the salt line.* A ceramic tile over each pair of electrodes seals off all air and eliminates corrosion at the salt line. *Thus, all the inherent advantages of submerged design are assured.*

To expose the electrodes for rapid removal, it is only necessary to lift the tile. The entire job can be handled by unskilled labor. Actual electrode changing time is less than an hour per pair.

Write for Bulletin 810 giving full details.

REPLACE AJAX REMOVABLE SUBMERGED ELECTRODES

. . . at absolute minimum labor cost
. . . without costly shutdowns
. . . without tearing down either furnace or pot

NOTE TO AJAX USERS! For as little as one fourth the cost of a new furnace, old Ajax Submerged Electrode Furnaces can be changed to this new removable electrode design.

AJAX ELECTRIC COMPANY
906 Frankford Ave., Philadelphia 23, Pa.
Associates: Ajax Engineering Corp.; Ajax Electrothermic Corp.

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DENVER 11, COLORADO: Richards & Associates, 2415—15th St.
DETROIT 35, MICH: J. E. Bullock, 19449 James Couzens Hwy.
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NEW YORK 6, N. Y.: Roger Stuart Brown, 136 Liberty St.
ORINDA, CALIF.: George H. Thurston, 1 Estates Court
PITTSBURGH 22, PA.: McQuiston & Gibson, 310 Renshaw Bldg.
SEATTLE 4, WASH.: H. E. Hartley, 230 Hudson St.
TONAWANDA, N. Y.: A. C. Towne, Jr., Charles Percival, Jr., 1456 Niagara Falls Blvd.

For more information, turn to Reader Service Card, Circle No. 529

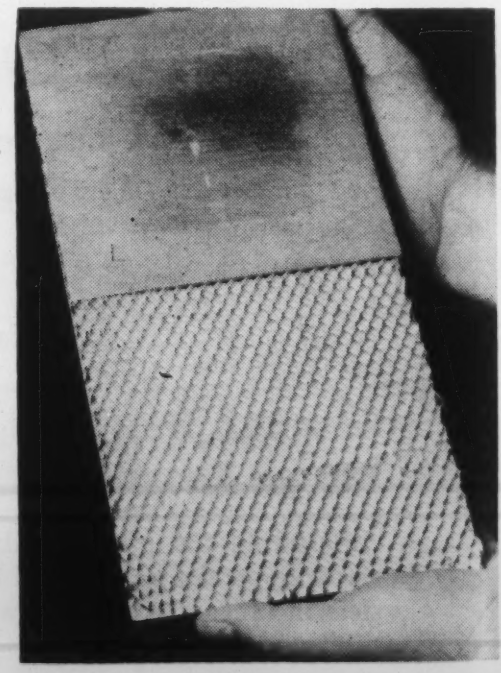
What's new IN MATERIALS

and a modified phenolic liquid adhesive (EC 1471). The phenolic adhesive is said to produce shear strengths in excess of those required by MIL-A-5090 B for structural bonding.

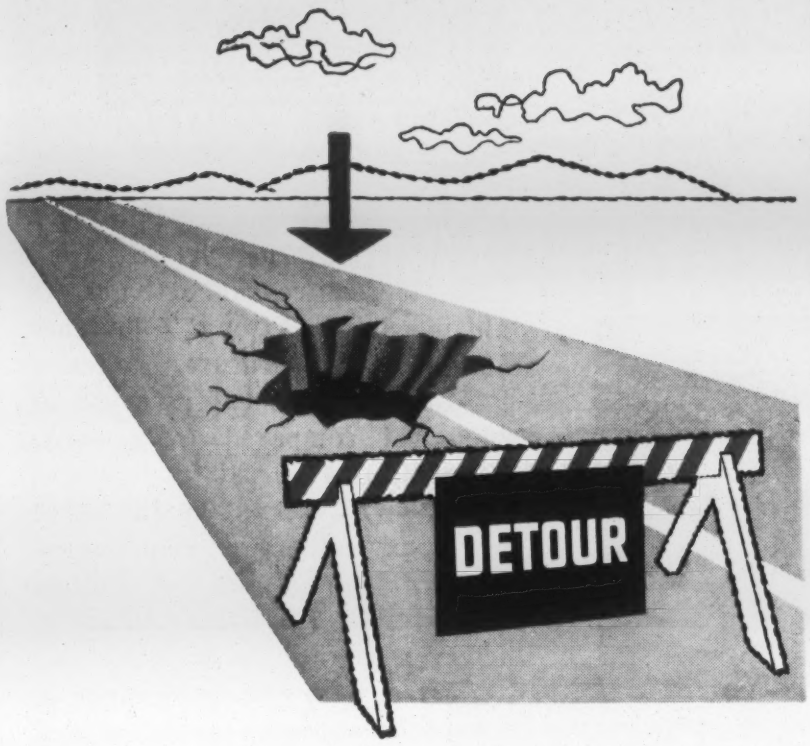
Three of the epoxy resin adhesives (EC-1294, EC-1474 and EC-1472) cure at room temperature under contact pressure without forming volatile by-products. All three can be used for bonding aluminum, brass, copper, steel and other metals to each other, to glass and to many plastics. The fourth epoxy, designated EC-1386, is a one-part adhesive.

EC-1294 adhesive cures to a clear, hard, light amber colored material that has good machining properties. It is recommended for permanent positioning of metal and plastics sleeves, bushings and inserts. It can be used at temperatures to 180 F. Filled with aluminum powder, the adhesive can also be used as a metallic-appearing sealer for filling or eliminating surface cracks, joints, pinholes and gashes on metal.

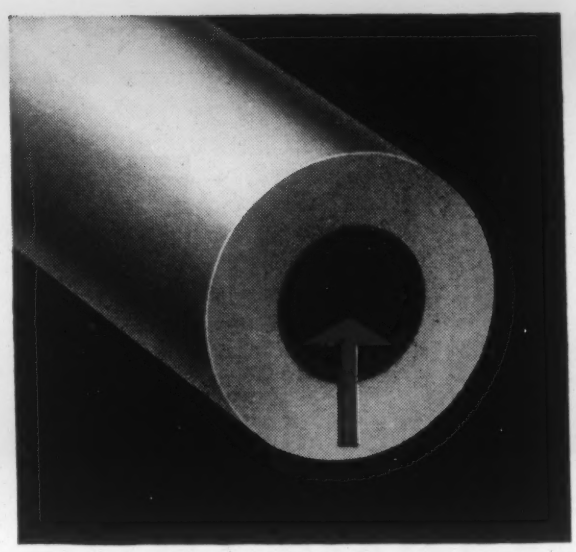
EC-1474, a lower cost adhesive, has been designed for use where cost is a major factor and good shear strengths and light color are not necessary. This adhesive



***Phenolic adhesive** can be used to bond metal facing (top) to honeycomb core.*



a hole here wastes time...



a hole here saves time

Crucible Hollow Tool Steel Bars save time — and money too — whenever you need ring-shaped steel parts, or tools with a center hole. The tool steel is drilled through when you get it! You don't need to bore, drill, hole-saw, cut off or rough-face. That's why they cut your production time, increase machine capacity — and reduce scrap losses.

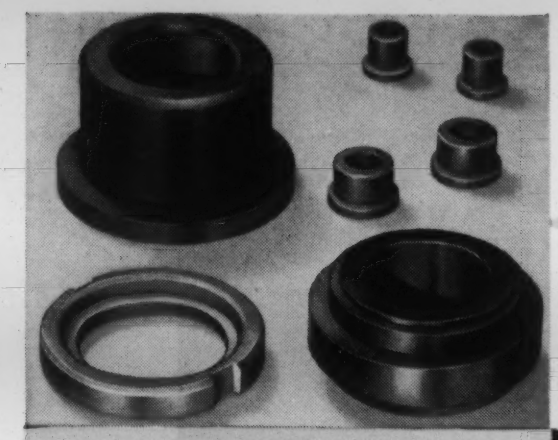
You can get these hollow bars in any of Crucible's famous quality tool steels, in almost any combination of OD and ID sizes. And you can get *immediate* delivery of five popular grades — KETOS oil-hardening; SANDERSON water-hardening; AIRDI 150 high carbon, high chromium; AIRKOOL air-hardening; and NU DIE V hot-work tool steels — from the Crucible warehouse near you.

Call your Crucible representative for the full story of how these steels can save time and money in your shop. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

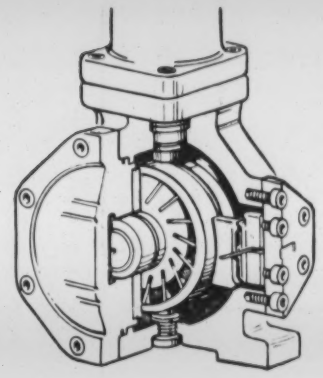
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

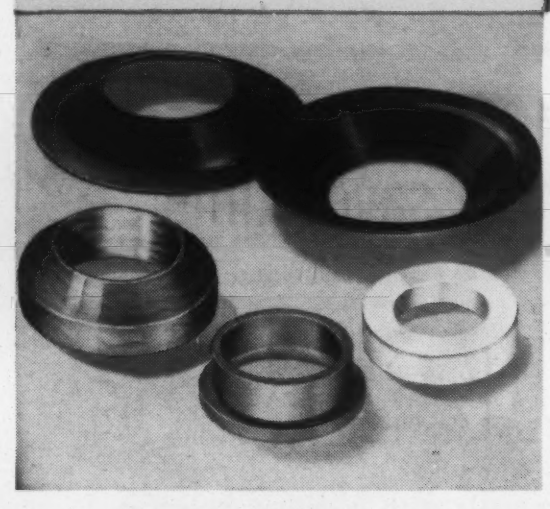
For more information, turn to Reader Service Card, Circle No. 546

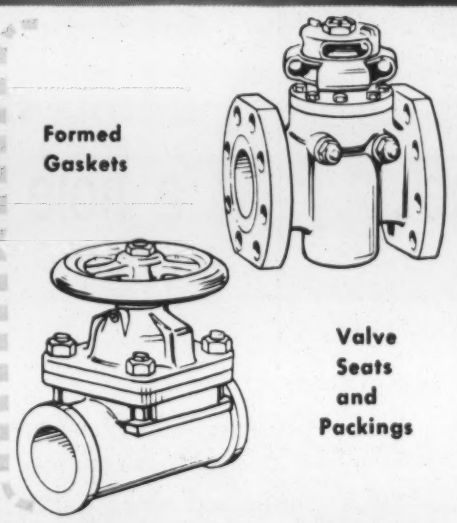


FOR:
Guide Bushings, Vanes and Wear Rings



HAVE YOU CONSIDERED THE IMPORTANT ADVANTAGES OF FILLED TEFLON*?





It has been definitely established that the value of Teflon can be considerably enhanced by the use of fillers in certain applications. Laboratory and field experience has demonstrated that the use of fillers permit Teflon to be more readily tailored to a wide variety of chemical, electrical and mechanical applications. Also, some mechanical properties can be improved. These include:

1) resistance to deformation under load
2) resistance to wear
3) thermal conductivity
4) compressive strength
5) hardness

By thus improving its properties, Teflon now offers even greater industrial potential. This is the reason filled Teflon has become an important item in the "John Crane" Chemlon® line of better Teflon products.

Chemlon is available with such fillers as glass fiber, carbon, graphite, copper and bronze, talc, calcium fluoride and other inorganic materials.

Tell us about your requirements. We'll tell you the advantages you can get from filled Chemlon. Request Bulletin T-104.

Crane Packing Company, 6460 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont

**DuPont Trademark*

For more information, turn to Reader Service Card, Circle No. 552

IN MATERIALS

has about the same bonding properties as EC-1294. As with EC-1294, it requires an activator to aid in curing. After a 7-day cure at room temperature, adhesive EC-1474 has a shear strength of 2000 psi compared to a shear strength of 4100 psi for adhesive EC-1294. *EC-1472*, like the other two epoxy adhesives, requires an activator for airing. A unique characteristic of this adhesive, however, is that its activator can be mixed with the base resin to provide a simple, easily mixed adhesive compound. After a 7-day room temperature cure, the adhesive has a shear strength of 3400 psi. It performs well at –65 F but should not be used in applications where temperatures above 120 F are encountered.

EC-1386, the other epoxy adhesive announced by 3M, is a one-part epoxy resin adhesive said to provide exceptionally good shear strengths without the addition of an accelerator or catalyst.

The one-part adhesive is said to provide unlimited working life. Working life of two-part epoxy adhesives is usually limited to minutes. The 100% solids, liquid adhesive is designed for metal bonding over a temperature range of –65 to 250 F. It gives good adhesion to brass, steel and aluminum and is suitable for applications where good shear strengths at room temperature or as high as 180 F are required. A curing temperature of 350 F is recommended. Since no volatile by-products are given off in curing, the adhesive is useful for bonding impervious surfaces. The cured material has a shear strength of 4600 psi up to 180 F. It is recommended for bonding metal facings to honeycomb core materials.

EC-1471, the modified phenolic adhesive, is said to have better filleting properties than nitrile phenolic adhesives, though it is less effective in this respect than most epoxy compounds. Peel

Studs for NELWELD process machined from Youngstown cold finished bars

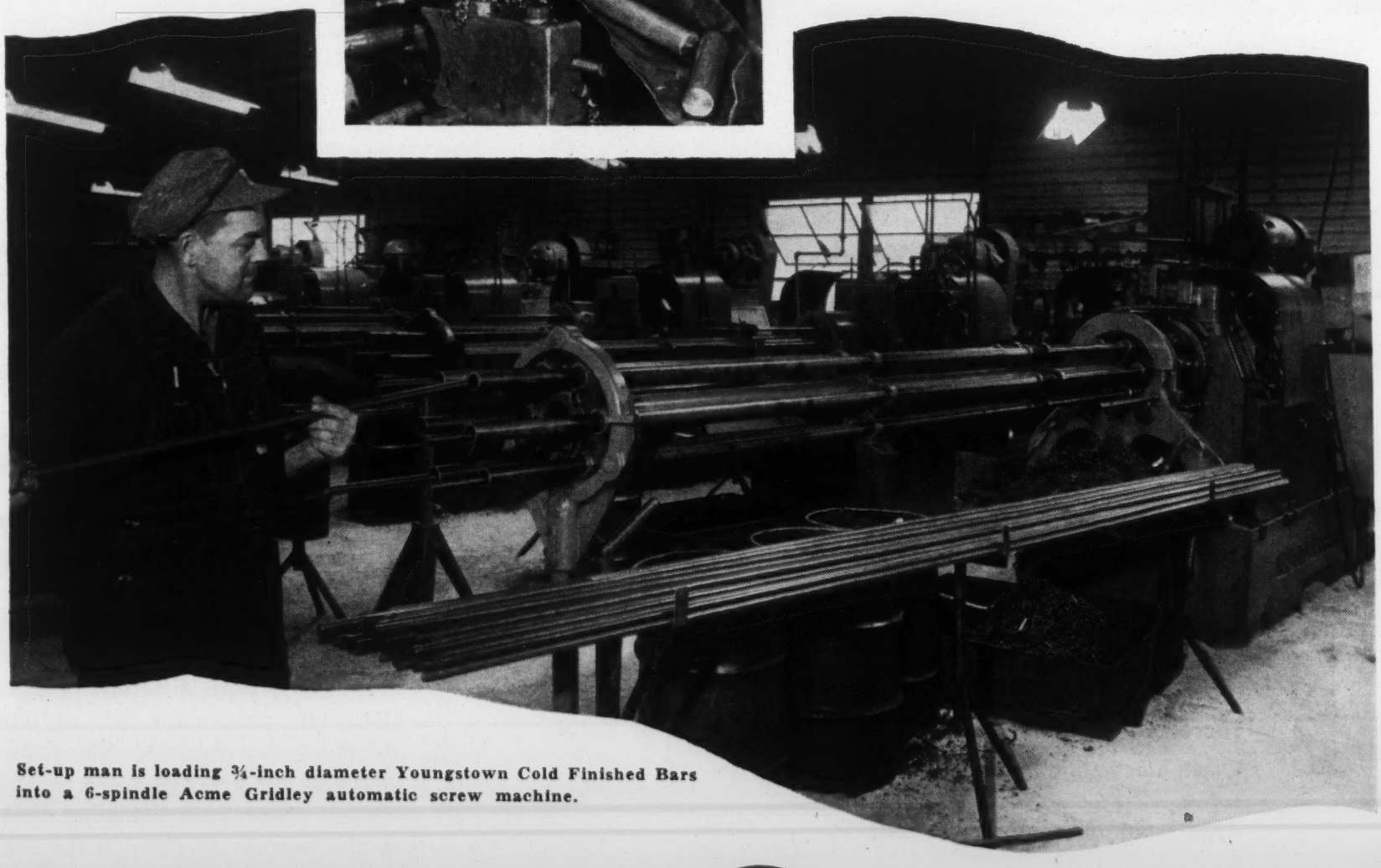
Progressive fabricators rely on the Nelweld method for fast, dependable end-welding of studs to steel surfaces. This novel electric arc process—utilizing flux-filled steel studs—substantially reduces direct fastening costs when used to replace conventional time-consuming methods such as drilling, tapping, hard welding, through-bolting or the securing of straps and rivets.

To maintain their world-wide reputation for product quality and uniformity, Nelson Stud Welding, a division of Gregory Industries, Inc., uses Youngstown Cold Finished Bars as the basic material for stud production.

Youngstown Cold Finished Bars provide high machinability and greater uniformity of composition, structure and surface finish to help you increase production of more uniform parts. Always specify Youngstown—it's your best assurance of quality.

Why not call or write your nearest Youngstown District Sales Office today for additional information or metallurgical assistance?

Close-up of studs being bored to accomodate their charge of flux (top collet) and then cut-off (center collet). Two finished Nelweld studs, shown in the pan in foreground, were machined simultaneously in the 6-position machine. First operation—feed out and face; second—bore; and third—cut-off.



Set-up man is loading ¾-inch diameter Youngstown Cold Finished Bars into a 6-spindle Acme Gridley automatic screw machine.

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon, Alloy and Yoloy Steel

General Offices - Youngstown 1, Ohio

District Sales Offices in Principal Cities

QUALITY · YOUNGSTOWN · SERVICE

Cold finished bars

For more information, turn to Reader Service Card, Circle No. 378

Get All the Facts about...

New 40 page Bulletin 54 just released contains detailed information on the complete line of Tinius Olsen Electomatic Testing Machines, which provide:

- **Positive testing speeds—even under load.**
- **Minimum of 100 to 1 ratio of testing ranges.**
- **Unlimited stroke.**
- **Widest selection of instrumentation available.**

These are just a few of the outstanding features of Tinius Olsen Electomatic Testing Machines described in this bulletin.

Write today for a copy of Bulletin 54.

TINIUS OLSEN
TESTING MACHINE COMPANY
2010 EASTON ROAD • WILLOW GROVE, PA.
Testing and Balancing Machines

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For more information, turn to Reader Service Card, Circle No. 478

What's new IN MATERIALS

strengths on bonded honeycomb structures are superior to those obtained with epoxies but lower than those obtained with nitrile phenolics. Room temperature shear strength of the adhesive is 5300 psi after curing 45 min at 350 F under 50-200 psi. The adhesive can be obtained also as a glass fabric-supported film.

Titanium Coatings Show Good Adhesion

An effective method for the electrodeposition of titanium on iron and steel has been developed. It uses a fused chloride bath containing a titanium-oxygen alloy powder and operated under a protective helium atmosphere.

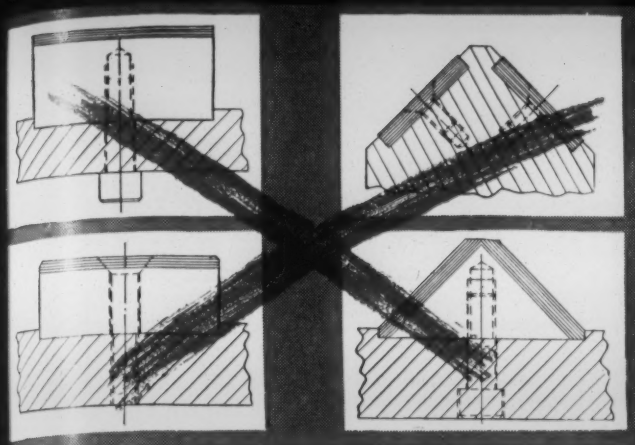
The method evolved from a series of tests conducted by Albert W. Schlechten, Martin E. Straumanis and Sheng Tai Shih, of the Missouri School of Mines and Metallurgy, for Wright Air Development Center. Results of the study are found in Part 3 of a three-part report available from the Office of Technical Services (PB-111794).

Oxides the key

Test results indicate that small, controlled amounts of oxygen, when introduced into molten alkali-chlorides, produce a workable titanium plating bath. The bath contains a charge of titanium-oxygen alloys that are prepared by heating metallic titanium powder and titanium dioxide in a vacuum furnace, then mixing these alloys with different proportions of potassium or sodium chloride. Hardness of the resultant coating depends more on the oxygen content of the alloy than on the amount of alloy in the salt bath; hardness drops off considerably as the oxygen content is increased.

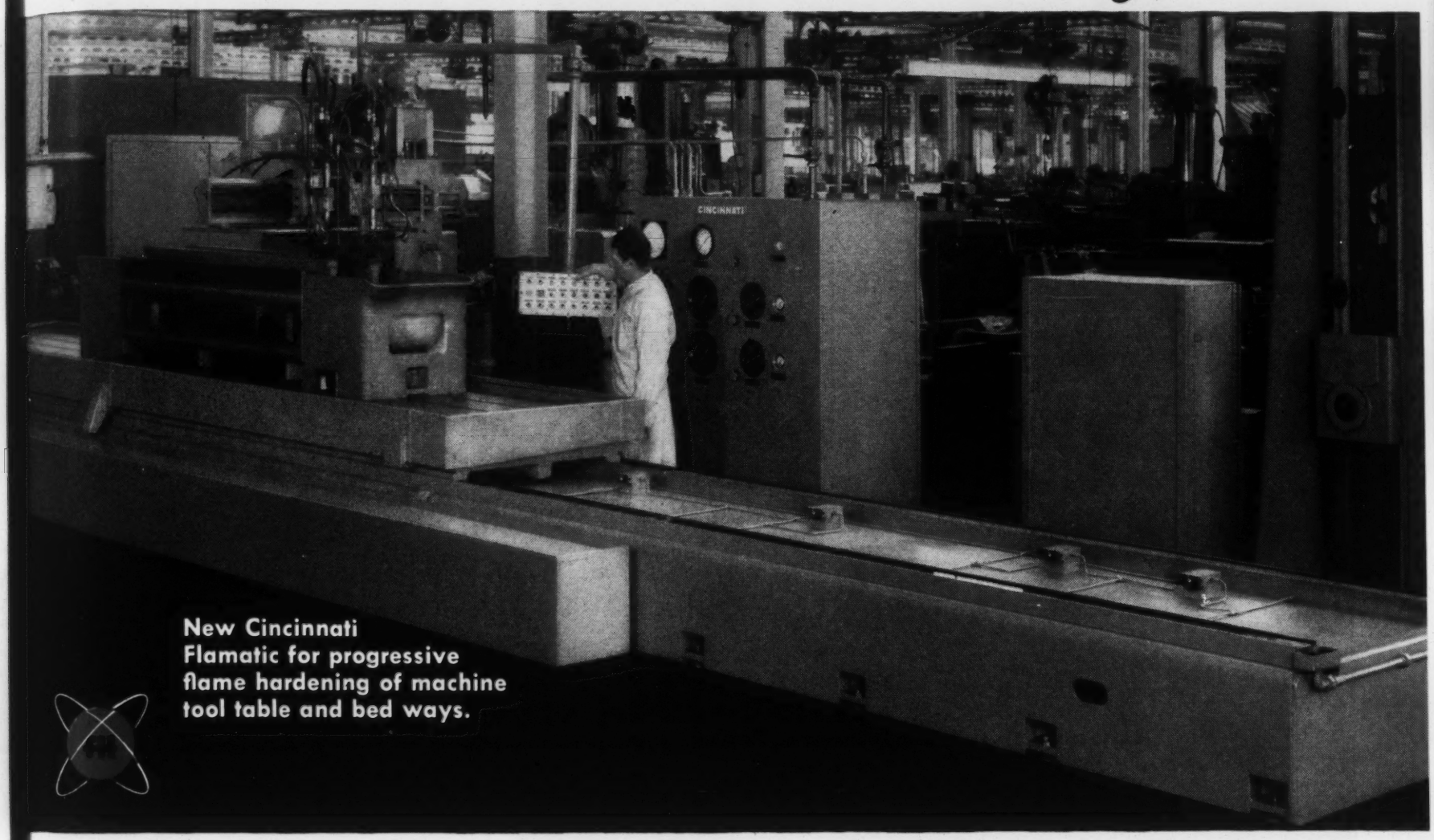
For example, bath containing 10% $Ti_{95}0_5$ and 90% potassium chloride produces a 0.0593-in. titanium coating with a Knoop

For more information, Circle No. 510 ➤



eliminate costly ways to get hardened ways...

use the **flamatic** *way!*



New Cincinnati Flamatic for progressive flame hardening of machine tool table and bed ways.

Cast iron machine tool table and bed ways are now being surface hardened on this new Cincinnati Flamatic®. Uniform hardness of Shore 75-80 is achieved. This Flamatic method results in substantial cost savings over methods currently employed of fastening hardened steel wear strips or sheets to cast or welded components in sliding contact.

The reciprocating work table of the Flamatic can accommodate castings up to 20 feet long x 44 inches wide x 40 inches high, on which integrally cast ways are to be hardened. Table feed is infinitely variable between 3″ and 15″ per min., and rapid traverse is at 25 ft. per min. Flame heads are mounted on a rail, powered for rapid positioning of the flame heads to the ways to be hardened. The flame head assembly includes water spray quench and a tracer mechanism, which at all times maintains the prescribed gap distance of the flame from the way . . . compensating for any distortion of the casting.

Oxy-acetelyne fuel gas is used; however, the unit will operate on propane or natural gas. Complete operating controls are located on a pendant station. Flame hardening of work such as columns, rolls, long bars and shafts, which can be held between centers on the table, is also accomplished.

Check into Flamatic surface hardening for savings in your production processes. Call in a Process Machinery Division field engineer.

CINCINNATI

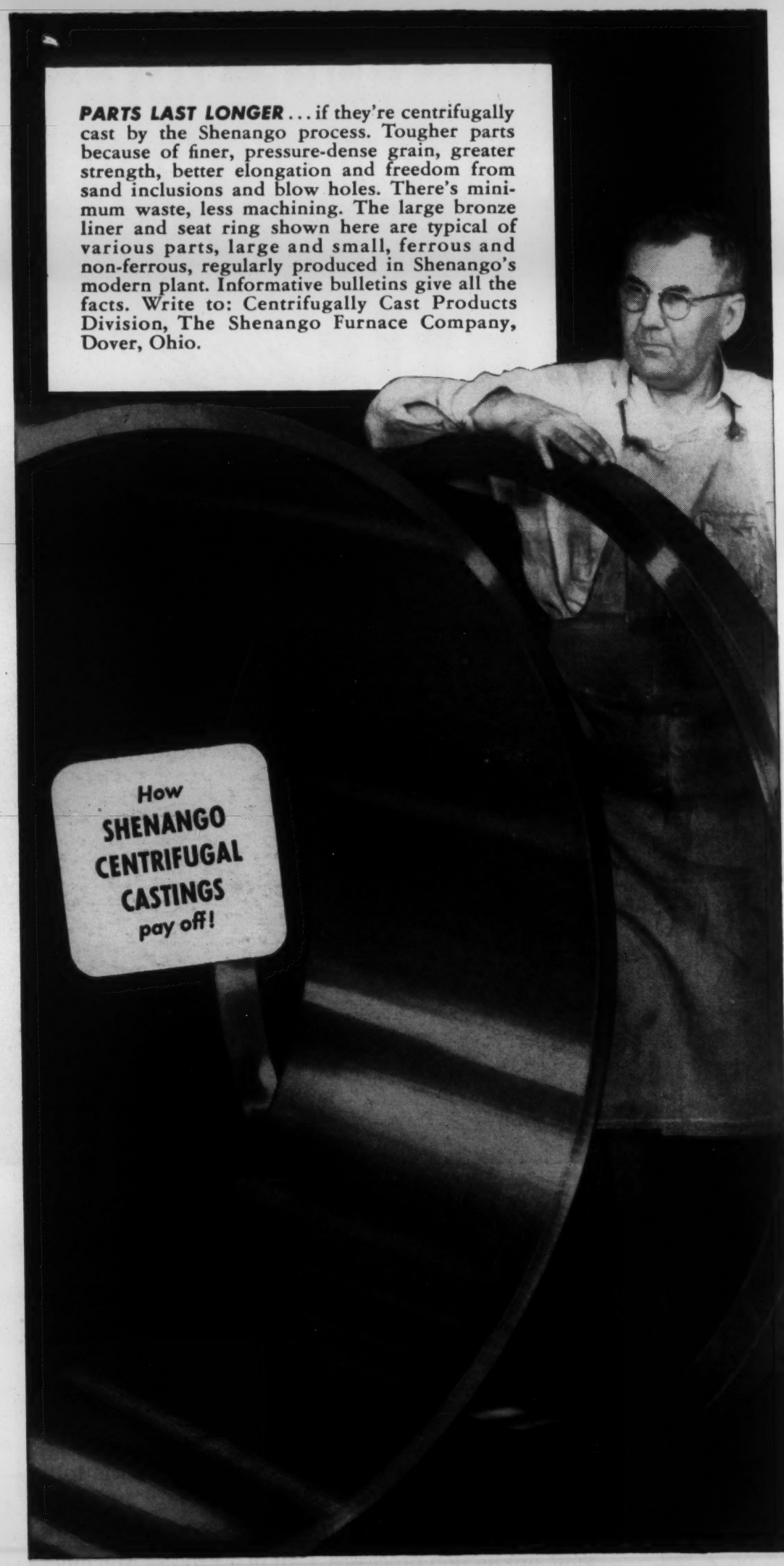
flamatic and inductron

hardening machines

PROCESS MACHINERY DIVISION

THE CINCINNATI MILLING MACHINE CO.

CINCINNATI 9, OHIO, U.S.A.



For more information, turn to Reader Service Card, Circle No. 462

hardness of 296 after 4 hr immersion at 1832 F. When the oxygen content of the bath is doubled (i.e., 10% $Ti_{95}0_{10}$), thickness of the titanium coating is only 0.0441 in. and Knoop hardness is only 162. (Hardness measurements in both cases made with a Knoop diamond indentor in a Tukon tester with an applied load of 2 kg.)

Recommended bath

In order to obtain a 0.002-in. titanium coating on ingot iron from a fused salt bath it is recommended that the bath contain 90% sodium chloride and 10% titanium-oxygen alloy, and that it be run for a period of 4 hr at 1832 F.

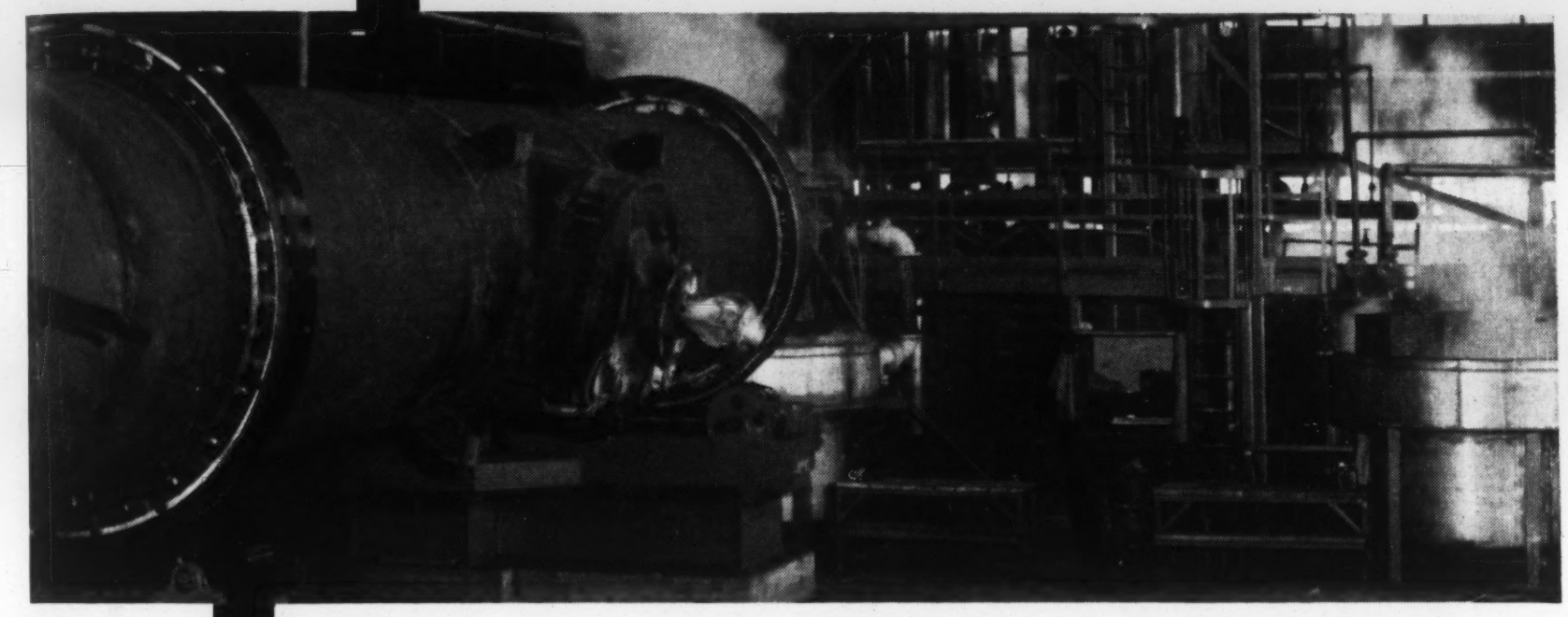
When the carbon content in steel exceeds 0.2% it is difficult to obtain a good titanium coating. Only spotty coatings are obtained when the carbon content of a steel reaches 0.36%. The difficulty seems to stem from the formation of titanium carbide in the bath, which bars the diffusion of titanium on the steel. Attempts to promote the formation of a diffusion layer by introducing silicon, aluminum and chromium into the bath were unsuccessful.

However, by introducing helium gas into the titanium charge, good coatings can be obtained. The charge is flushed with helium gas and then introduced into the molten bath, where the helium is allowed to escape. The specimens, checked with nitric acid and copper sulfate tests, show only a few minute areas not covered with titanium. These tests confirm the fact that large objects can be titanized.

Physical properties

Titanium coatings deposited on a variety of base materials from an assortment of fused salt baths increase in thickness with time and temperature. For instance, a bath containing 90% potassium chloride and 10% titanium-oxygen alloy produces a titanium

this new plant can help conserve scarce nickel



kanigen®

replaces expensive clad materials and alloys

With Kanigen (a new nickel alloy) you can coat several items with the amount of nickel normally used for one. In General American's new plant at Sharon, Pa., large and intricate shapes are being uniformly coated with Kanigen on a production-line basis.

Kanigen has special application in the chemical and petroleum industries for protection against corrosion and product contamination. For example, Kanigen-coated carbon steel can be used for valves, fittings, piping and vessels. Many parts utilized in the printing, aircraft and food industries formerly fabricated of alloys and clad materials are now Kanigen-coated mild steel—resulting in significant savings to the manufacturer and user.

Kanigen is a unique material—not a substitute for electroplating. Kanigen-coated surfaces provide corrosion-resistance plus hardness and uniformity. A very thin coating of Kanigen on aluminum permits excellent solderability.

If you have a problem that Kanigen might solve or if you'd like further information, write or call us.

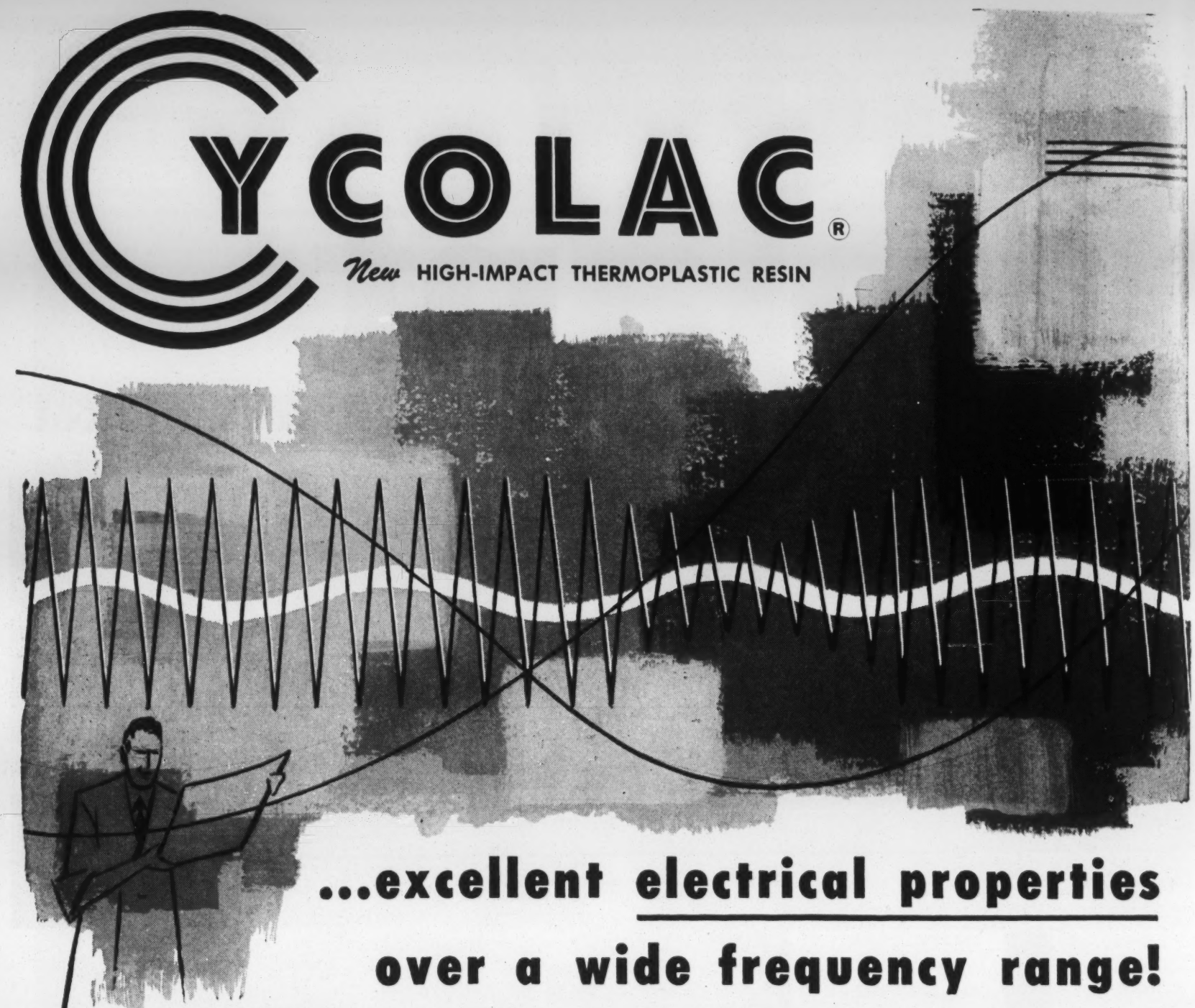
KANIGEN GENERAL AMERICAN TRADE MARK

KANIGEN DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South La Salle Street, Chicago 90, Illinois
Plants at East Chicago, Ind., Compton, Calif. and Sharon, Pa.

For more information, turn to Reader Service Card, Circle No. 577

CYCOLAC®

New HIGH-IMPACT THERMOPLASTIC RESIN



...excellent electrical properties over a wide frequency range!

CYCOLAC has outstanding electrical properties over a wide frequency range, low moisture pick-up, and a low burn rate. In addition, Cycolac has high sag temperature, is colorful, very tough over a wide temperature range and is rigid as well as light in weight.

THE PERFECT RESIN FOR THE MANUFACTURE OF ANY PRODUCT THAT DEMANDS . . .

- Chemical Resistance
- Lightweight
- Non-Corrosion
- Dimensional Stability
- High Impact Strength
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MARBON CHEMICAL . . . *Precision Resins for Precision Made Products*

For more information, turn to Reader Service Card, Circle No. 532

coating 0.0305 in. thick after 4 hr at 1742 F. When temperature is increased to 1832 F the resultant coating is 0.0593 in. thick. When coating time is increased from 2 hr to 6 hr at 1832 F, thickness of the coating increases from 0.0382 in. to 0.0693 in. Hardness increases with coating thickness.

Bend tests indicate that the titanium coating holds fast to the the side of the specimen stressed in tension and only tears apart when the brittle base metal under the coating is ripped by the severity of the bend. There is a tendency for some of the coatings to buckle in strips. This is noted especially on the compression side of bent specimens, the strips climbing on one another and flaking off.

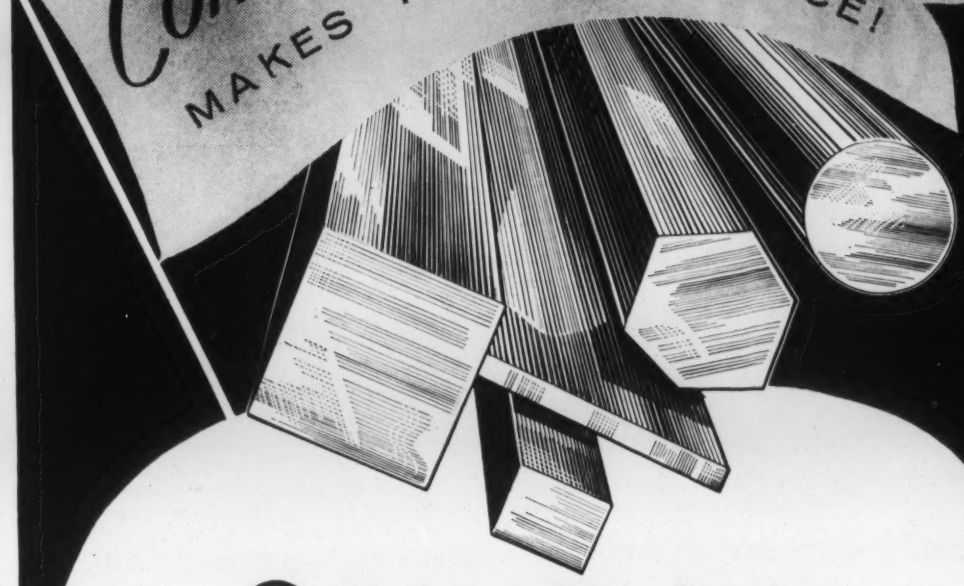
Tensile tests, like bend tests, show that the coating is adherent under reasonable stress, and that it cracks, checks and flakes off only when the base metal is deformed beyond its elastic limit.

Acrylic Molding Resin Has Improved Flow

An improved formulation of Lucite 140 acrylic resin, with better thermal stability and flow than regular Lucite 140, has been announced by *E. I. du Pont de Nemours & Co.*, Wilmington 98, Del. The resin, now being shipped from the company's Parkersberg, W. Va., plant, is said to have an upper molding temperature limit greater than that of any other acrylic resin. Tests indicate that the new formulation is stable at 20 to 30 F above the maximum temperature of other acrylic resins.

Because of the greater flow made possible by higher molding temperatures, the new acrylic resin is said to provide thin parts with fewer surface blemishes and flow lines, as well as thicker parts without voids. The higher molding temperature is

Controlled Quality
MAKES THE DIFFERENCE!



① Faster Machining
② Longer Tool Life
③ Finer Finish

WITH

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COLD FINISHED

LEADED STEELS

AND

SCREW STOCKS

Complete range of analyses in quality-controlled free-machining LEADED STEELS and SCREW STOCKS to your specifications

COLD FINISHED STEELS

Carbon, Alloy and Leaded Steels
Turned and Polished Shafting
Turned and Ground Shafting • Wide Flats up to 14"
All types of furnace treated Steels

SPECIALISTS IN COLD FINISHED STEELS EXCLUSIVELY

WYCKOFF STEEL COMPANY

GENERAL OFFICES:
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Works: Ambridge, Pa.—Chicago, Ill., Newark, N.J.—Putnam, Conn.

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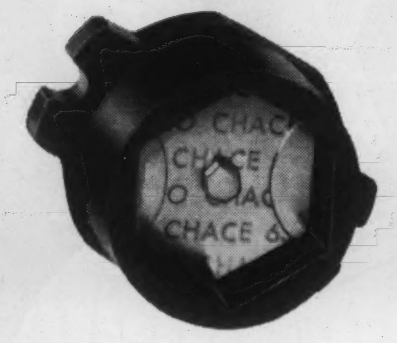
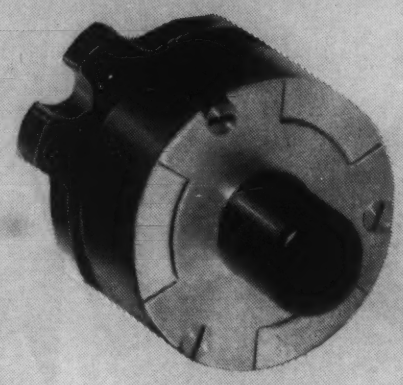
HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE

RBM

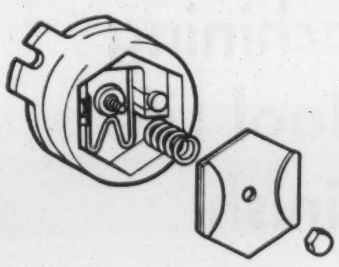
MOTOR PROTECTOR



AUTOMATIC RESET—#91300, #91400

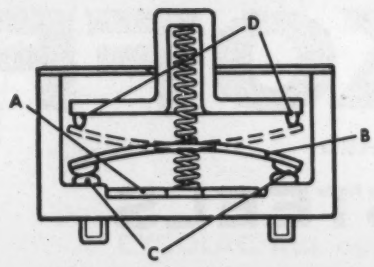


MANUAL RESET—#92300, #91400



A PRODUCT OF RBM DIVISION OF
ESSEX WIRE CORP.
LOGANSPORT, IND.

After years of development by RBM Division of Essex Wire Corp., and now in volume production, this bimetal motor over-load protector provides overload protection for split phase or capacitor motors such as are used in many household appliances. It may also be used with 110/220 volt motors of heavier capacity. The disc-type element is sensitive so as to give instant response to locked rotor current, yet carry starting surges and protect against running over-loads. The calibration to trip at 105° (also 120°) allows for ambient compensation for varying temperatures within the motor. The box shape of the terminals prevents soldering spatter and the double break contact provides long contact life. The snap-action disc element is fabricated from Chace Thermostatic Bimetal.



Here's how the manual reset protector works: The heater wire (A) carries a normal load but is heated by locked rotor currents or running overload currents. The heater in turn heats the thermostatic bimetal disc element (B) until at the calibrated temperature it snaps into the reverse shape, opening the contact points (C); when the reset plunger is depressed after correction of the failure, the two buttons (D) contact the bimetal element, forcing it to snap back into its original shape with contacts closed.

Remember Chace when you design for temperature actuation or indication, or for protection of valuable equipment. Dependable Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal and many pages of engineering data.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

For more information, turn to Reader Service Card, Circle No. 560

What's new IN MATERIALS

also said to result in parts that are more resistant to solvents and distortion by heat, yet retain all the other properties of the regular Lucite 140. The higher molding temperature is possible because of the resin's improved thermal stability.

The improved Lucite 140, priced the same as regular Lucite 140, is expected to be useful in auto stop light lenses, speedometer dials, refrigerator parts, washer panels and other parts where complex or hard to fill forms are required. Lucite 140 is available in natural and stock colors.

Odorless Rubber

A synthetic rubber compound that is claimed to be odorless and tasteless has recently been announced by *Goshen Rubber Co.*, Goshen, Ind. Known as Compound No. 1317, the synthetic rubber compound can be used over a temperature range of −30 to 225 F.

The nontoxic compound has a tensile strength of 2300 psi an elongation of 325% and a Durometer A hardness of 78. The material is designed for seals and other rubber parts in food machinery and beverage dispensing units.

Paint Siliconizing Protects Hot Steel

Recent tests conducted on various surface coatings by Sam Tour & Co. for Wright Air Development Center indicate that both paint siliconizing and paint chromizing offer promise as protective, heat resistant surface treatments for plain carbon and low alloy steels.

The paint used for siliconizing and chromizing the test panels consists of a suspension or slurry containing: 1) either silicon or chromium metal powder, 2) a flu-

UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

Plastisol coatings give protection "in depth"

New chromate dips cut costs of zinc finishing

Three new dips which work at extreme dilutions have recently been added to the Unichrome line.

NEW ECONOMY

All Unichrome Dips provide chromate solutions known for the long service they give before they need replacing. At the low make-up concentrations of these three new Dips, cost for finishing drops to a new low.

MATCHED TO THE NEED

Unichrome Dip Solutions form corrosion-resistant finishes integral with zinc, improve and protect its eye appeal.

But chromate dips are active solutions which strip away zinc as well as convert its surface into an attractive but inactive film. As a result, the type of equipment used and the operating time or cycle affect results. The differing needs of manual or automatic finishing must be satisfied to produce the color, corrosion resistance, uniformity of finish—as well as the economy desired. Since no single chromate solution is equally suitable for all applications, many specialized Unichrome Dip Compounds are made available.

Metal & Thermit will gladly recommend the proper dip to meet specific needs. Simply submit details of product and requirements.

Unichrome is a trademark of Metal & Thermit Corp.

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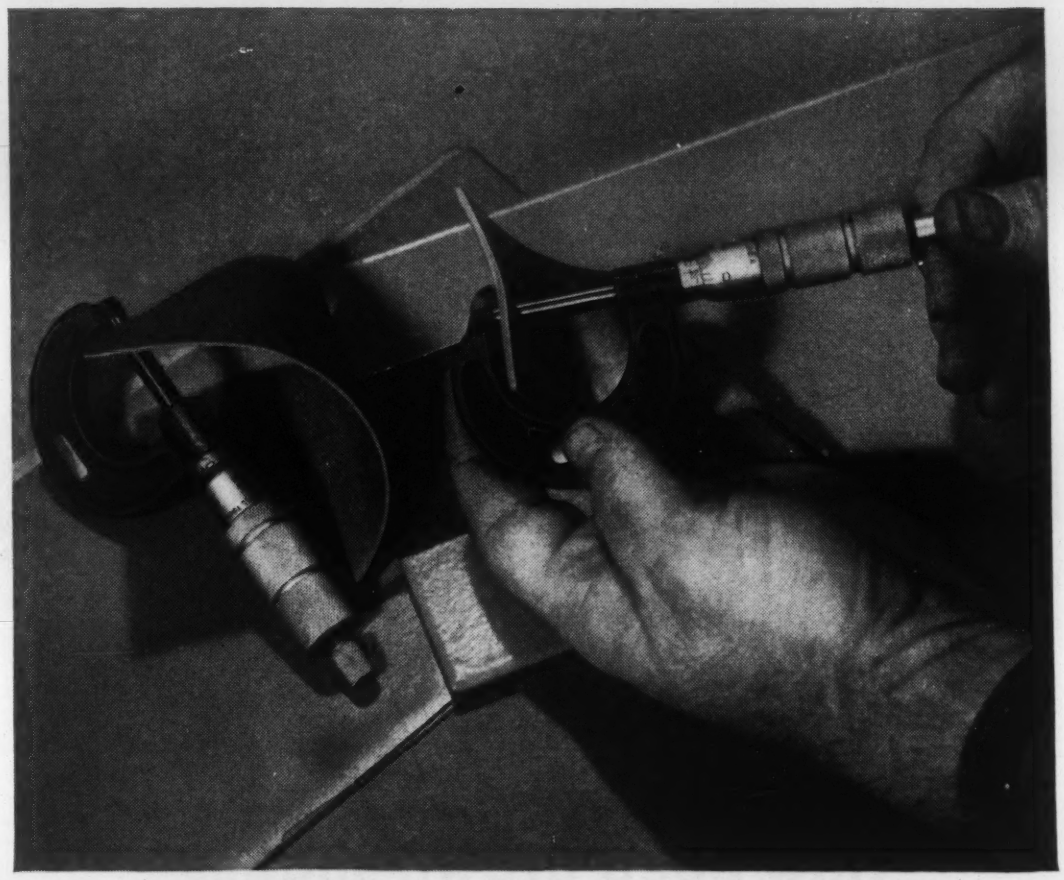
East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, Ont.



Unichrome Plastisols provide single coat thicknesses approaching those of sheet materials. Thinner coats can also be applied as desired.

Vinyl plastisols form films with excellent resistance to chemical attack. But it's the *thickness* of resilient film buildup that really sets a plastisol coating apart from the usual coating . . . and makes ordinary metals coated with plastisols fit for heavy duty.

APPLICATION MADE EASY

Thickness of 60 mils or more per coat can be sprayed with Unichrome "Super 5300" Coating. Products dipped into Unichrome Series 4000 Coating can have a film thickness up to $\frac{3}{16}$ inch. Such body means *pore-free* protection, ample section to absorb damaging impact, and a *long-wearing* abrasion-resistant finish.

Many plants specializing in applying plastisols have enlarged facilities to handle bigger and bigger parts and products. Spraying or dipping is practical on *any* size product for which there are facilities to heat and hold the coated object at 350° to 365°F for curing.

OTHER ADVANTAGES OFFERED

Plastisol coated products also get *seamless* protection against acids, alkalies, moisture, and other corrosives. The finish has satiny gloss, resists abrasion, deadens sound, insulates electrically, doesn't age and crack.

Record service has been delivered by Unichrome Plastisols on such diverse applications as pump impellers, dishwashing racks, agitators, ductwork, screens, cart bumpers, tool and work holders, plating racks, thumbtacks, enclosed tanks . . . to cite a few. Obviously, Unichrome Plastisols are versatile. Send for Bulletin VP-2 for more ideas.

For more information, turn to Reader Service Card, Circle No. 513

How deep drawn shapes can lower unit costs

Weight...strength...appearance...reduced costs—all are part of modern, cost-cutting design for modern products. That's why Hackney deep drawn shapes and shells are outdating and replacing heavy forged, cast or welded pipe parts. For Hackney helps shape up a better product—lighter weight, stronger, more streamlined, with resistance to vibrations.

You can design from a wide range of shapes and sizes: cylindrical, spherical, conical, tapered—in capacities from a quart to 70 gallons.

These deep drawn shapes and shells have paid off in condensing units, liquid receivers, pneumatic and hydraulic products—just to name a few. Send a sketch of your plans and let Hackney engineers help you with the details. They'll be happy to consult with you on metal specifications, location of openings and fittings as you specify.

Pressed Steel Tank Company

Manufacturer of Hackney Products

1442 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service Card, Circle No. 513

oride, 3) glass frits of low and high melting points, 4) a liquid vehicle containing suspension agents and binders, and 5) a volatile thinner.

Practically no preparation of the steel surface is necessary. Several coats of the paint are applied with intermediate air drying. After preheating, the coatings are fired in an open furnace at 1,900 to 1,950 F for 1 to 3 hr for chromizing, and 1,750 to 1,850 F for 10 to 30 min for siliconizing.

As the heating proceeds, the paint binders in both the coatings burn away and the glass frits melt to form a molten protective and reactive coating. After removal from the furnace, the panels are cooled. The glass freezes, shrinks and cracks away, leaving the treated surfaces relatively clean.

The test results discussed here are from a two-part Dept. of Commerce report entitled "Evaluation of Surface Treatments for Low Alloy Steels." The two parts are available from the Office of Technical Services as PB 121087 and PB 121088.

Coatings tested

Paint chromizing (0.0012 in. thick) and paint siliconizing (0.-013 in. thick) were done on both SAE 1010 low carbon and titanium-boron steels. The performance of these coatings was compared with that of many other coatings. Low carbon steels were coated with hot dip 13% silicon-aluminum—0.0039 in. (also tested on titanium-boron steel — 0.0046 in.), sprayed and fused aluminum —0.007 in., electroless nickel—0.006 in., electroplated nickel—0.0009 in., silicone-aluminum paint —0.0009 in., corronized finish—0.0032 in., Sicon paint 3 x 222—0.0006 in., Sicon paint 7 x 273—0.0005 in., cadmium electroplate—0.0015 in., and epoxy paint—0.004 in.

The test procedure consisted of exposure to two types of artificially created environments. The

86% of your welding costs are in labor and overhead...

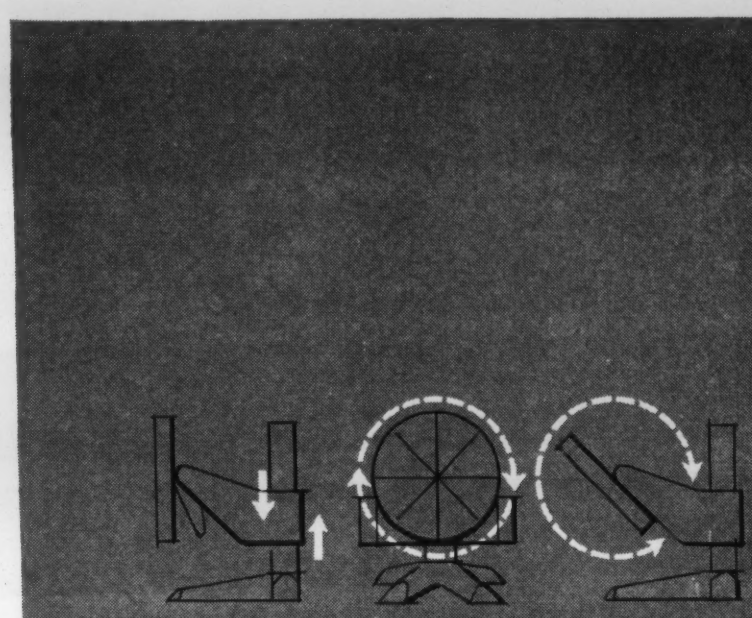
P&H

welding positioners can slice that in half!

The greatest savings you can realize in your welding operation lie in how you *handle* your weldments.

Are your operators waiting for cranes . . . rolling heavy weldments laboriously by hand . . . welding in awkward, tiring positions that affect both operator efficiency *and* weld quality? These are the factors that send labor and overhead costs skyrocketing. These are the factors that account for 86¢ out of each welding dollar, however, we'll show you how the use of P&H Welding Positioners frequently cut this cost *in half*.

Interested? Of course you are. Write for the facts. Address: W. R. Stephens, Sales Manager, Dept. 303G, Welding Division, Harnischfeger Corp., Milwaukee 46, Wis.



All standard P&H welding positioners give full elevation even under capacity load, 360° rotation, 135° tilt.

Photo courtesy Lakeside Bridge & Steel Co., Milwaukee, Wisconsin.

HARNISCHFEGER

P&H WELDERS · ELECTRODES · POSITIONERS

Milwaukee 46, Wisconsin

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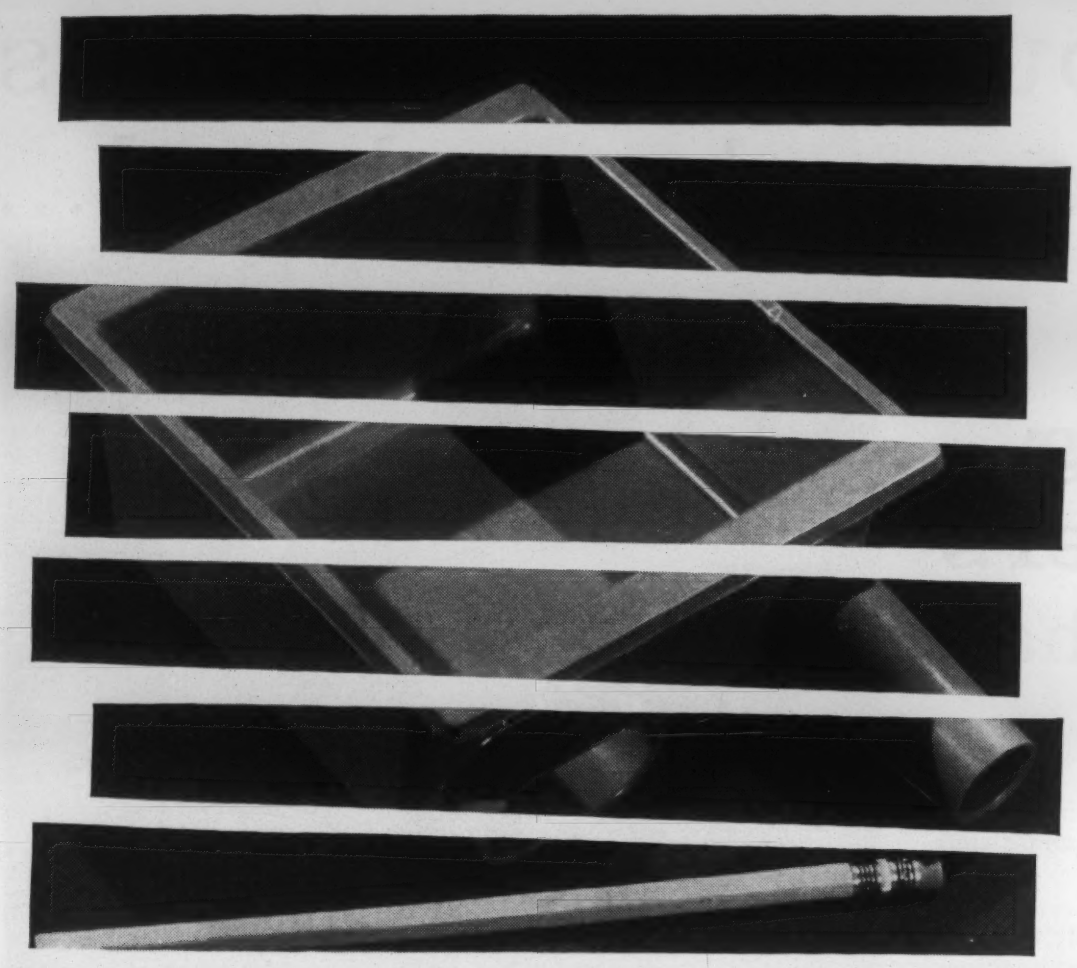
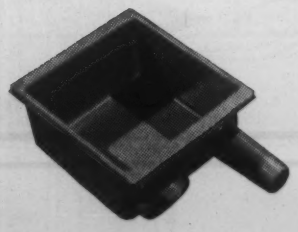


take another look...at plastic molding insurance!

Continuous production of your plastic moldings at Kurz-Kasch is insured by (1) a stand-by power system for our molding presses; (2) a policy of designing dies that will last; (3) a staff of top-notch tool makers to keep dies in shape; (4) two generations of specializing in thermo-setting plastic moldings. We know more ways to stay out of trouble than some molders know how to get in.

The dishwasher part shown meets a trick set of specs: smoothness for appearance; glass reinforcing for high impact; good resistance to hot, soapy water; color to match attractive trim.

For a quote you can depend on . . . call Kurz-Kasch.



Specialists in thermo-setting plastics for 41 years

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For more information, turn to Reader Service Card, Circle No. 549

first step was cyclic exposure for one week at various temperatures in a combustion atmosphere. The second step was cyclic exposure for one week in an alternate condensation corrosion test unit at room temperature or slightly above.

The combustion atmosphere was obtained by the use of a kerosene torch plus suitable additives and an excess of air. Some of the additives used were sulfur dioxide, lead oxide, bromine, vanadium pentoxide and lead bromide.

The atmosphere produced by the kerosene torch was directed into a full muffle in a temperature controlled furnace where the coated panels were tested at temperatures of 600, 800, 1,000, 1,200 and 1,400 F for 6 hr each day for 5 continuous days. During the remaining 18 hr of each day the panels remained in the closed muffle with no heat and no artificial atmosphere being introduced; this was the alternate condensation method.

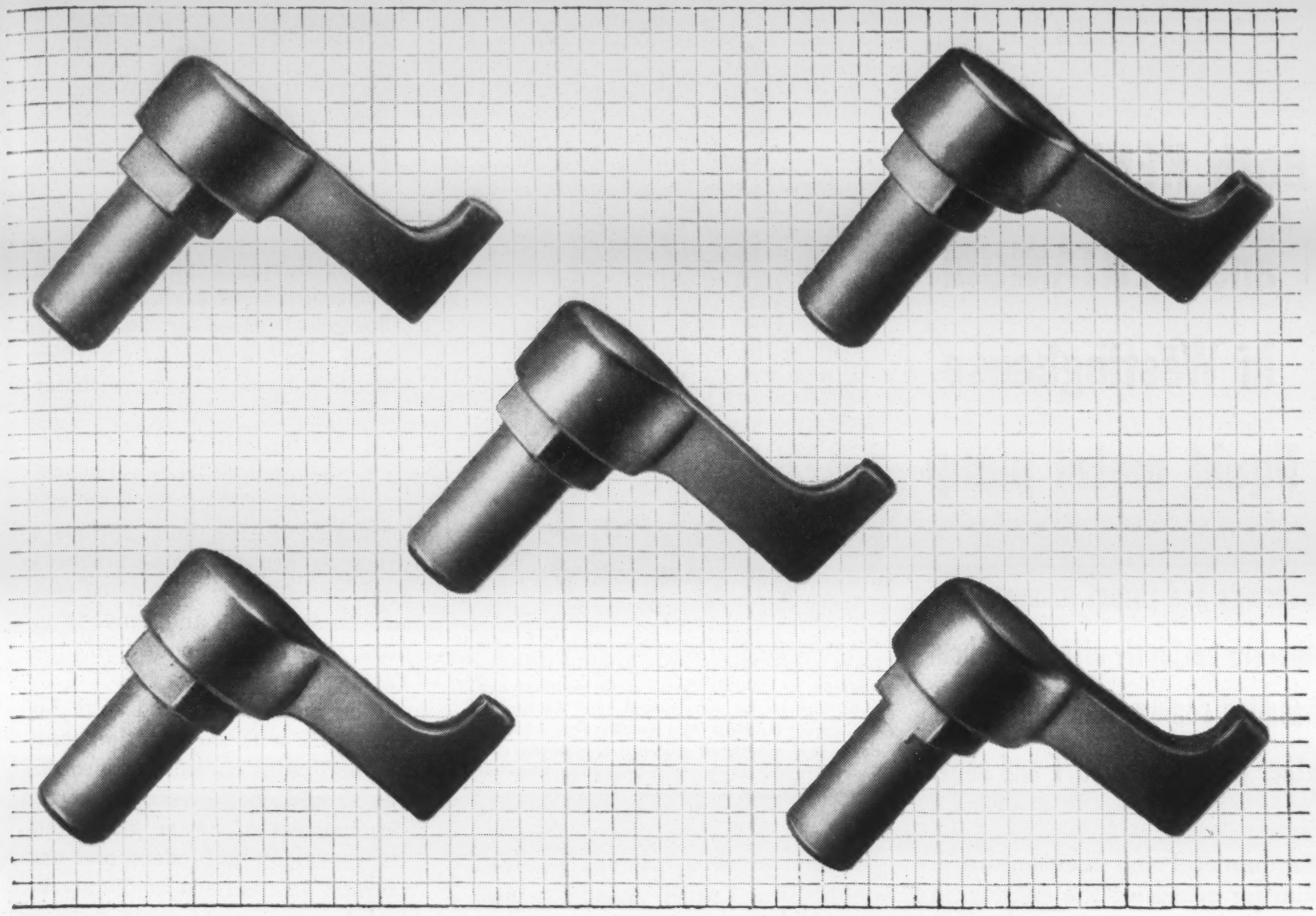
Conclusions

The test showed a vast difference between exposure in an atmosphere containing the products of combustion of hydrocarbon fuels and exposure at the same or higher temperatures in air alone. The test also indicated that it is possible to differentiate between poor and good coatings from the standpoint of porosity, adherence, heat resistance and protection against corrosion. Such paint coatings as Sicon 3 x 222, Sicon 7 x 273 and epoxy appeared completely unaffected by furnace exposure to 600 F but failed quickly when exposed to alternate condensation.

Some specific conclusions:

1. Sprayed and sealed aluminum (metallizing) protects panels to 800F. Sprayed and fused aluminum panels withstand temperatures above 1,200 F.

2. Paint chromized titanium-boron steels are protected against



Cam Segment—weighs less than an ounce, measures less than ½ inch.

Investment-Casting improves part ... eliminates hours of machining

HAYNES' investment-casting process made it possible to mass-produce a small intricately-shaped part in a hard, abrasion-resistant alloy. The part, a cam segment, is less than one-half inch long, and weighs only a fraction of an ounce. It is cast to size. Only one simple threading operation is required to prepare it for operation.

The cam segment is used in a control instrument and rides against a valve shaft under pressures up to 35 lb. per sq. inch. At one time it was cast from a relatively soft metal and machined to final dimensions. The machining time for each cam was several hours—an expensive operation. The performance of the part was unsatisfactory because the metal used was selected for ease of machining—and could not stand up under the abrasive conditions.

The investment-cast segments are now made of type 410 stainless steel. They have been used for over one million operations and still show no signs of wear.

The freedom to select alloys for performance, regardless of how difficult they may be to machine, is one of the big advantages of HAYNES' investment-casting method. Intricate shapes in hard metals can be cast close to size, eliminating many machining operations. For full details on the process, write to our general sales office in Kokomo, Indiana, or any of the district sales offices listed below.

HAYNES
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ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

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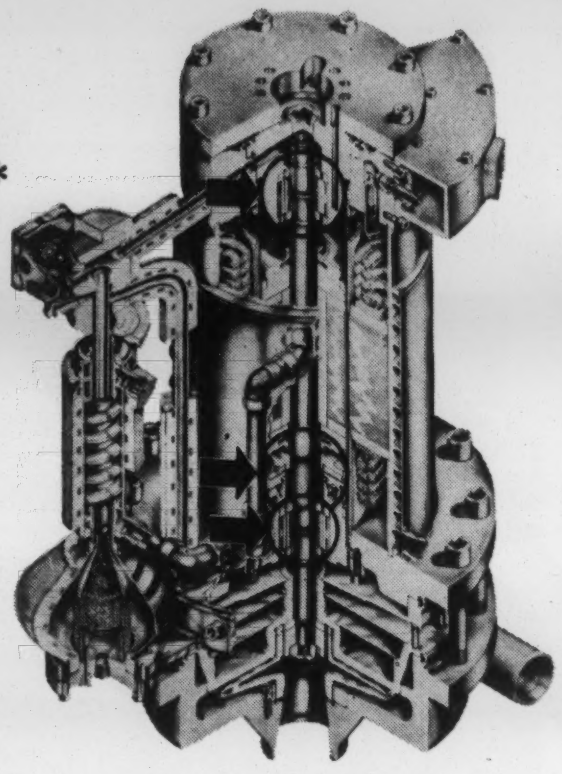
Both KENNAMETAL* and KENTANIUM* in Westinghouse liquid metal pump



Cut-away view of Westinghouse pump to handle liquid sodium, NaK or other metals at temperatures up to 1500°F. Circles show bearings and thrust runners of Kennametal and Kentanium, which meet the most rigid specifications of tolerances and quality of material to provide *continuous, 100% leak-proof pumping operation for extended periods.*

Bearings and thrust runners operate perfectly after 2000 hours handling sodium, NaK and other metals at 1050°F and above

Kennametal and Kentanium are sharing in one of the engineering advancements of the year . . . the Westinghouse centrifugal liquid metal pump designed for the atomic power industry. Kennametal grade K9** and Kentanium K138A** were selected for the vital bearing and thrust runner parts which are lubricated by liquid metal with a film much thinner than oil lubricants. Surfaces must not corrode and must be highly wear resistant to maintain leak-proof seals . . . rugged requirements which Kennametal and Kentanium have met under gruelling tests.

RUGGED ENDURANCE TEST: After 500 hours of operation with the pump stream at 1050°F (and 120 psi head), the pump was taken down and the Kennametal and Kentanium parts examined. They showed no change. Now, after 2000 hours of around-the-clock operation, these parts continue operation in apparent perfect condition. Larger Westinghouse pumps now being built to handle sodium and NaK at 4000 gpm and 1500°F at 250 psi pump head include similar parts of Kennametal and Kentanium.

These applications suggest the use of Kennametal or Kentanium wherever two surfaces rub together or are forced together . . . especially under severe conditions as encountered in handling liquid metals or other difficult-to-handle materials. Such applications might include valve seats, rings, bushings, sleeves on shafts, etc. Kennametal engineers are prepared to assist you. They have years of accumulated experience in the development of hard carbide metals to meet special requirements. Call or write KENNAMETAL INC., Latrobe, Pennsylvania.

*Trademarks of a series of sintered tungsten and titanium carbides.

**Approved, Bureau of Ships Specification, Carbide Stocks for Bearings, MIL-C-18482, 20/4/55.

INDUSTRY AND KENNAMETAL ...Partners in Progress

see our catalog in S or write for copy

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scaling during heat treatment at temperatures as high as 2,100 F. Chromized cases on low carbon steels are continuous, uniform, ductile layers that withstand bending and forming operations and can be welded.

3. Siliconized titanium-boron steels are resistant to scaling or oxidation during long periods of time in air at temperatures as high as 1,350 F. Siliconized cases are hard, brittle and zonal in nature, with a continuous thin interfacial zone.

The authors contend that further work with the paint siliconizing and paint chromizing processes should be directed toward development of better glass frits, improvement in binders and suspension agents used in the slurry, and development of spray methods for application of the two paints.

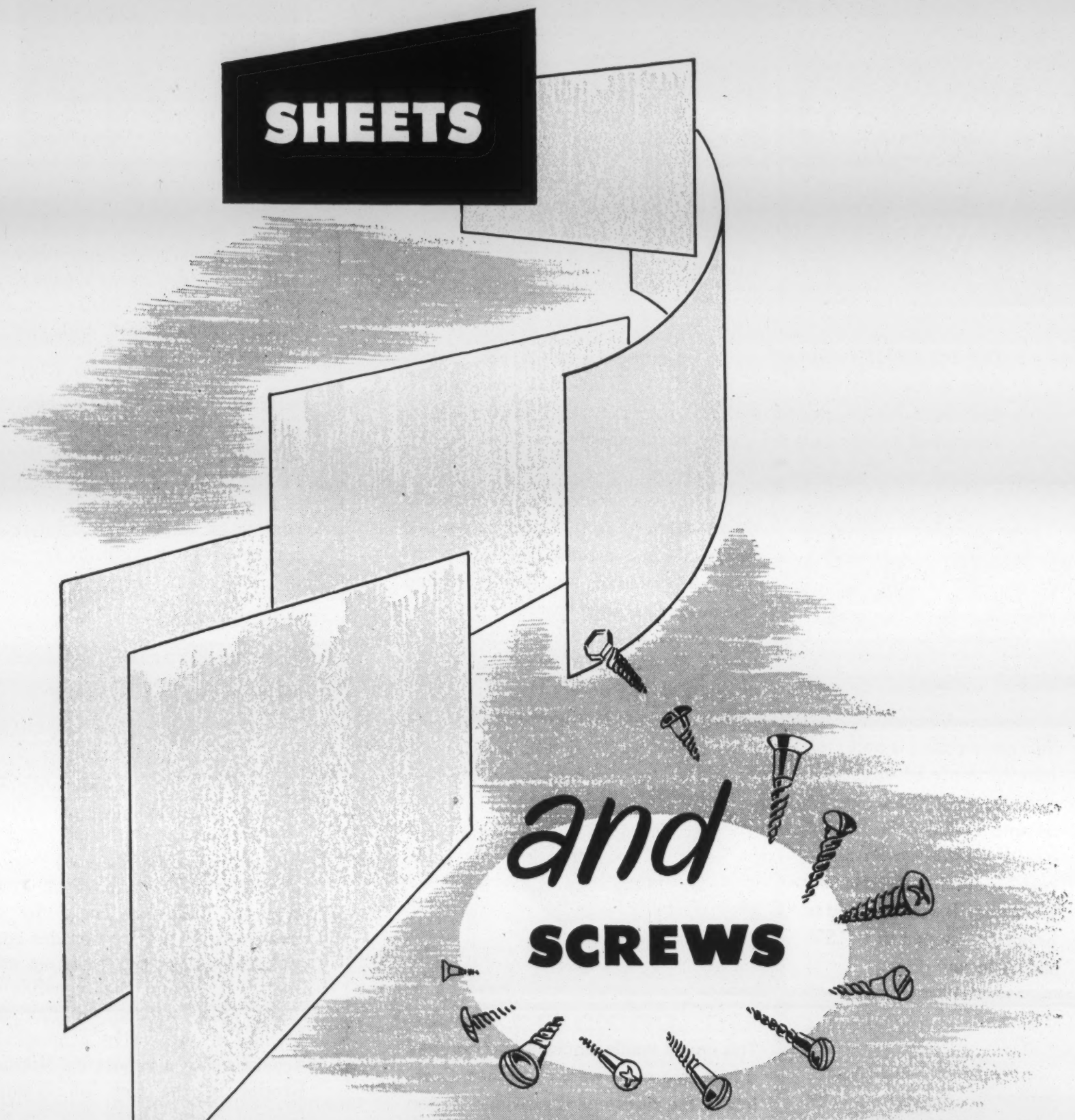
Synthetic Enamel Acts Like Porcelain

Duracron, a "synthetic porcelain enamel" based on a unique series of thermosetting acrylic resins, has recently been developed by *Pittsburgh Plate Glass Co.*, 632 Fort Duquesne Blvd., Pittsburgh 22, Pa.

Said to be a new type of coating that looks and performs more like porcelain than any other known organic finish, the material is claimed to be a radical departure from baking enamels now in use. It is said to offer in one coat the same protection and finish that present two-coat finishing systems provide. The synthetic porcelain enamel has good adhesion to metal surfaces and primers.

Supplied in a complete range of colors, Duracron may be of special interest for refrigerators, home laundry equipment and air conditioning equipment.

Comparative tests show that the new coating provides considerable improvement over alkyd-melamine



Seems like a strange combination, doesn't it?
But it helps us make an important point. More than 20,000 corrosion resistant items are stocked in our seven conveniently located warehouses. You name it — we have it. And if you are not completely sure of the material you want, we can and will gladly give you our unbiased opinion of the right material to do the job.

Whether it be sheets or screws, or tubes, or tacks, we can act as your metal Supermarket to supply you — quickly! Leading metal producers such as Alcoa, Inco and Anaconda are only a few of the many quality companies we represent.

You'll find it pays to call WHITEHEAD first.

ALUMINUM • BRASS • BRONZE • CLAD METALS • COPPER • MONEL • NICKEL • INCONEL • PRIMARY NICKEL & FERRO ALLOYS • PLASTICS • STAINLESS STEEL
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WHITEHEAD METAL PRODUCTS COMPANY, INC.

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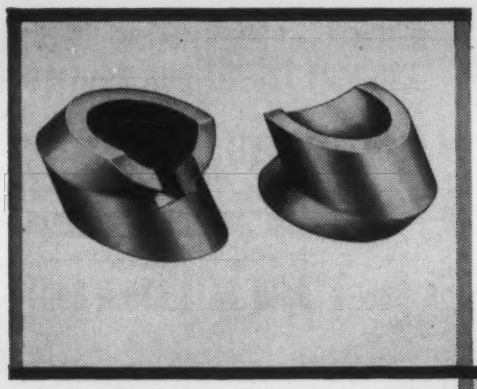
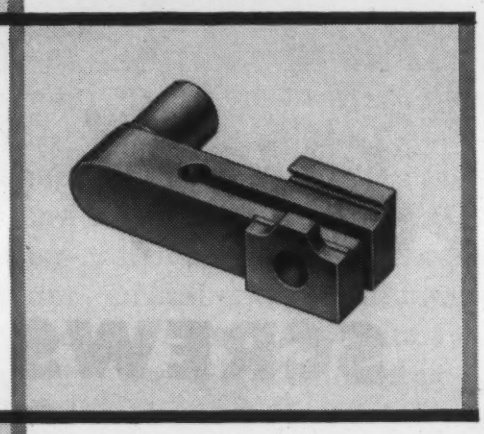
Basic Considerations in Selecting alloys . . . . . for your INVESTMENT CASTINGS

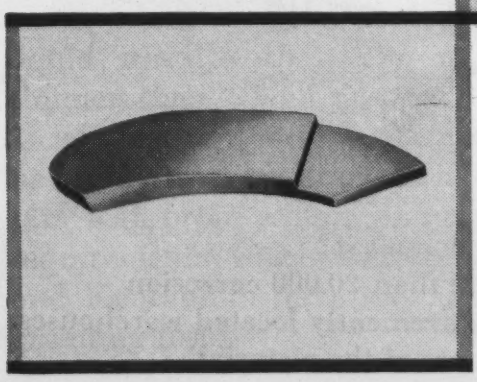
DO YOU KNOW THAT . . . an investment casting produced from a low cost metal may be MORE EXPENSIVE than one cast from higher priced material that may also have characteristics better suited to your requirements.



These angle connectors were originally investment cast in mild steel, a low cost material. To overcome corrosion problems, 303 stainless was substituted and because of its better castibility there was no increase in cost. Now, silicon brass is being used at a 10% saving on the original selling price.

This gage mount is an excellent example of unusually good casting characteristics of one metal offsetting a decidedly higher material cost. Originally priced in SAE 8620 steel, it was changed to beryllium copper at a 15% saving in unit price.





This simple textile machine part requires a high degree of wear resistance. Casting in the right metal provided better properties at lower cost than when machined from tool steel.

Get more complete information for this is only a small part of the story telling how the right metal selection for investment castings can often increase efficiency and reduce costs.

WRITE today for Bulletin 116-205 . . . it's FREE!

HITCHINER
Manufacturing Company
MILFORD 7, NEW HAMPSHIRE
REPRESENTATIVES IN PRINCIPAL CITIES

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What's new IN MATERIALS

enamels in: color and gloss retention on overbake; chemical and detergent resistance; humidity and salt spray resistance; grease and stain resistance; hardness; flexibility; and impact and mar resistance.

Cost of the material, though slightly higher per gallon than ordinary baking enamels, is said to be less in the long run because of the single coat application.

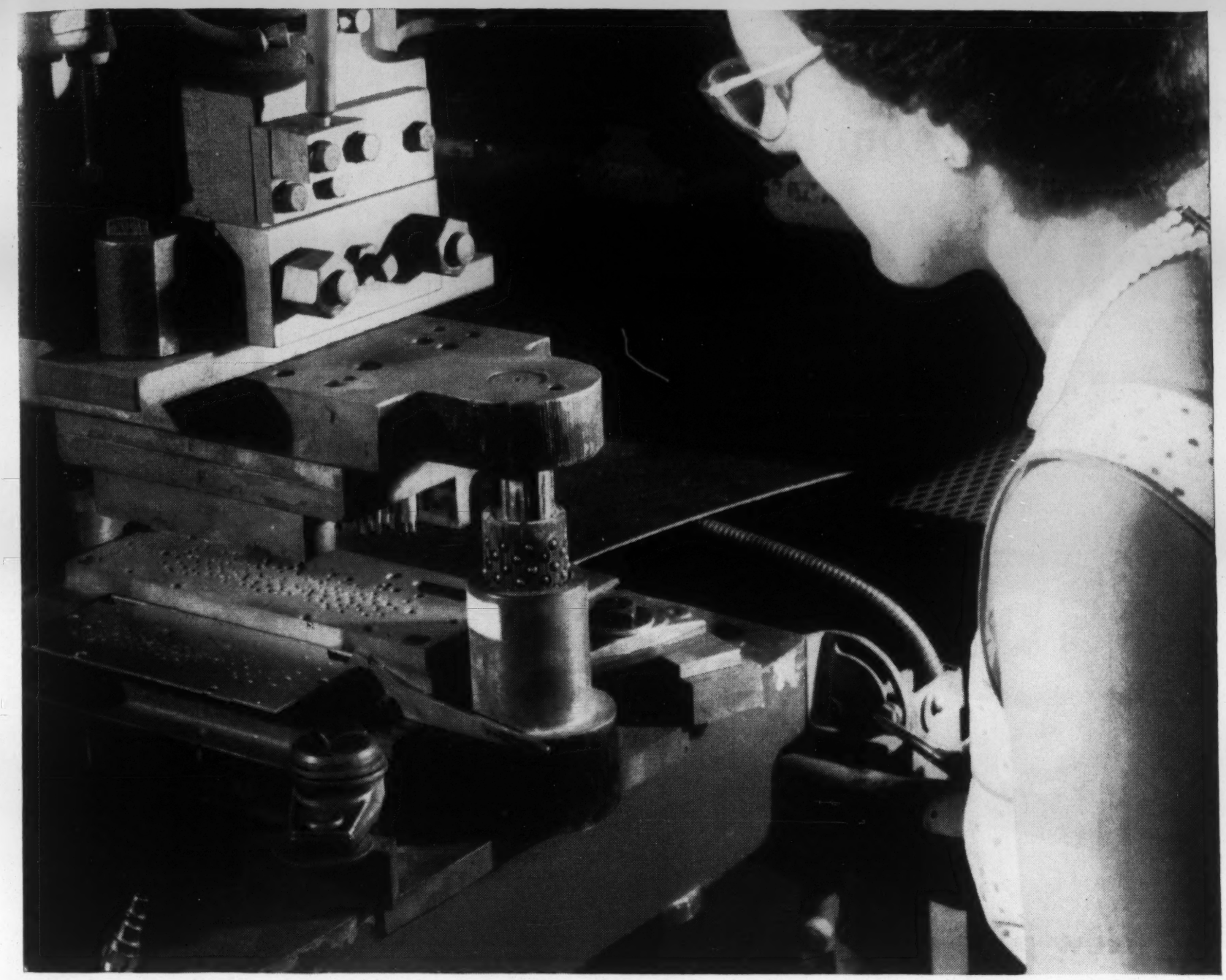
Field tests are presently being conducted on the material to determine its applicability for building panels.

Silver Brazing Alloys Made Self-Fluxing

The wettability of low carbon steel with pure silver and silver-base alloys is considerably impaired by incomplete protection against exposure to air due to diffusion of oxygen through layers of molten brazing material. If the rate of diffusion could be decreased or if the iron oxides could be reduced by the brazing alloy itself, it would be possible to braze steel without a flux and without a protective atmosphere. According to a report by Nikolajs Bredzs in the Oct '56 *Welding Journal*, such alloys can be produced by combining metals so that one metal (or combination of metals) protects the molten filler metal against the oxygen of the air, and the other metal (or combination of metals) reduces the iron oxides on the steel surfaces. Some of the specific conclusions reached by the author are:

1. Small additions of barium and, especially, lithium considerably improve the wettability of liquid silver on steel. In addition, these two metals, which have a high affinity for oxygen, apparently reduce iron oxides at practical brazing temperatures.

2. For protection against oxygen diffusion, small additions of nickel and/or tin, can be used to



New copper-clad **MICARTA**®

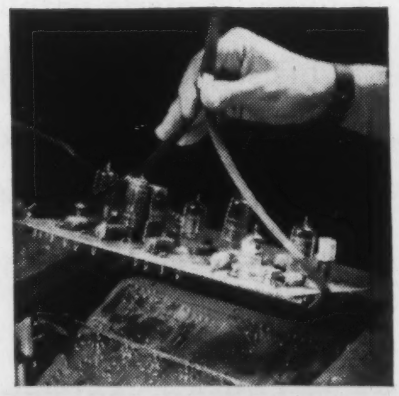
is easy to cold punch—no cracking, no chipping!

All holes in new H-3032 copper-clad MICARTA can be cold punched right on the assembly line in one operation, and there's no cracking, breaking or chipping. That is one of the reasons why this new laminate cuts costs and production time of printed circuits.

In addition, copper-clad MICARTA speeds up soldering, without the normal accompaniment of an increase in rejects and missed connections.

High bond strength — from 10 to 13 pounds versus an industry standard of six pounds — is retained even after heating and cooling are repeated many times, due to a new adhesive process.

If you have a circuit assembly problem, copper-clad MICARTA may be the answer. For further information and for technical data, write to Westinghouse Electric Corporation, MICARTA Division, Hampton, South Carolina. J-06626



CAN BE DIP SOLDERED!
MICARTA will not blister — even when dip soldered for 10 seconds at 500° F. A special adhesive actually increases adhesive strength during soldering.

YOU CAN BE SURE...IF IT'S Westinghouse

For more information, turn to Reader Service Card, Circle No. 495

Available
NOW from Fansteel...

MOLYBDENUM SHEET

FROM STOCK

Seven Popular Sizes of Fansfeel Moly "D" Now Available for 1-Week Delivery:

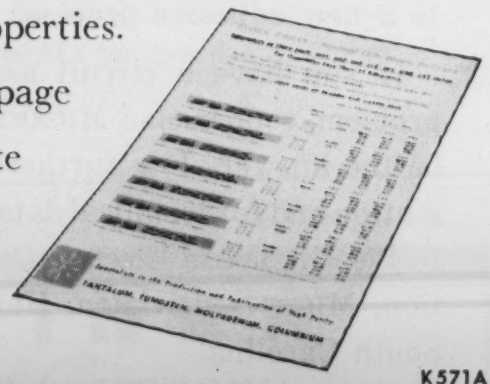
.005" .015"
.007" .020"
.010" .025"
.012"

New price bulletin now ready.

For the first time since the beginning of its commercial production, molybdenum is now available from "on hand" warehouse stocks. Delivery is made within one week.

This stock is not ordinary molybdenum sheet; it is Fansteel Moly "D" Sheet, recognized throughout the world for its superior ductility, workability and deep-drawing properties.

Be sure to send for the new six-page price bulletin containing complete prices for both molybdenum stock items and special mill runs.



K571A

FANSTEEL METALLURGICAL CORPORATION
NORTH CHICAGO, ILLINOIS, U. S. A.

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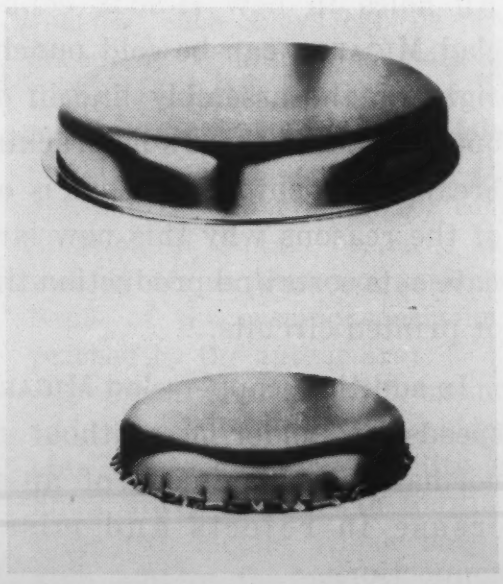
make self-fluxing silver brazing alloys.

3. Lithium-bearing silver alloys and lithium-bearing copper alloys can be successfully used for brazing plain carbon steels, as well as stainless steels, without flux or reducing atmospheres. Tensile strength of such joints is quite high.

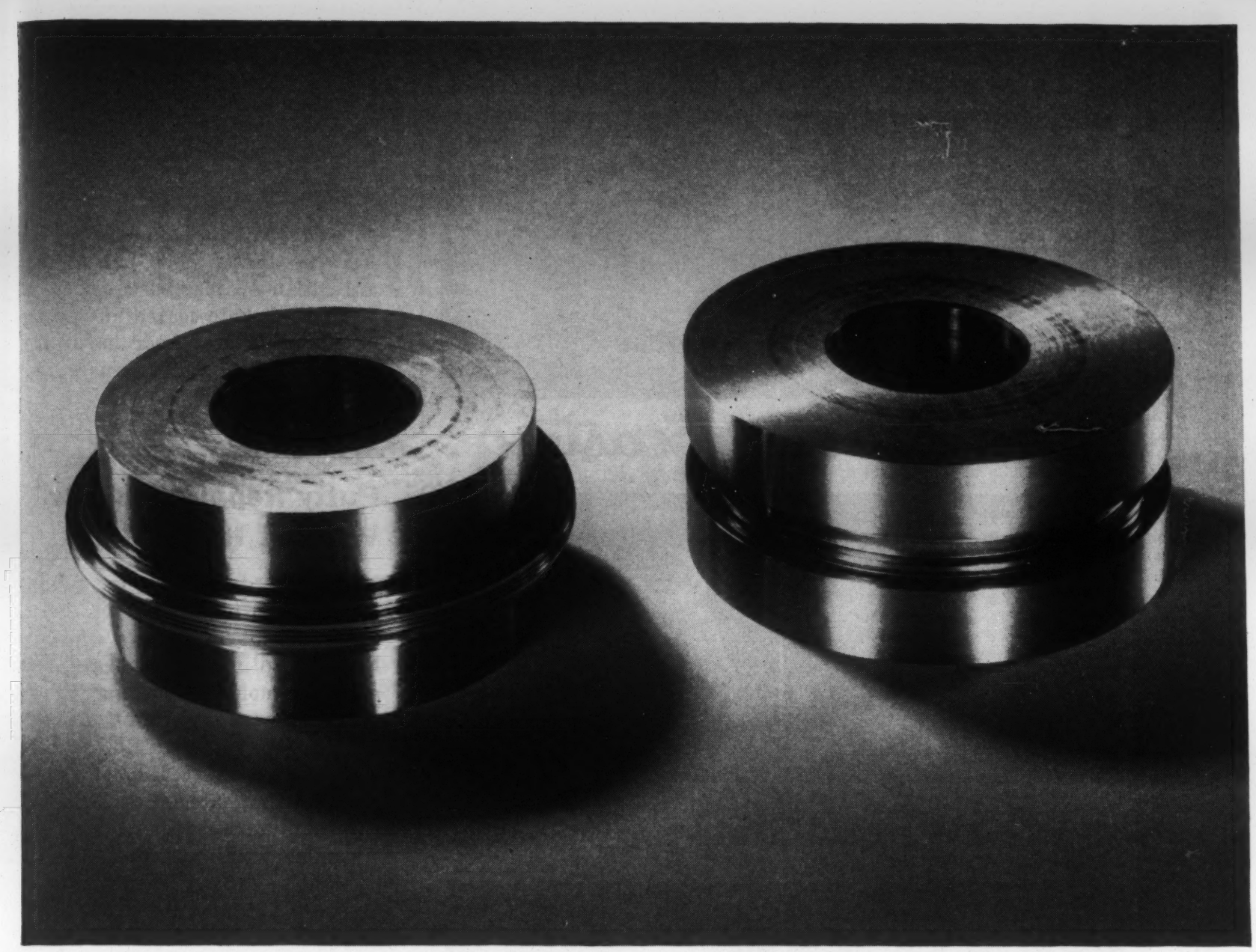
Tough 'Brass' Prefinish Available on Metals

A line of prefinished metal sheet and strip with a baked synthetic copper and brass finish is now available from *American Nickeloid Co.*, Peru, Ill. Called Bakekote, the coating contains a thermosetting resin which produces a tough, adherent, elastic film said to provide maximum gloss, flexibility and chemical and abrasion resistance.

According to the company, metals coated with the film can be drawn, stamped, press and roll formed, and seamed with no peeling, cracking or flaking of the protective film. A salt spray test conducted over a 48-hr period on preplated copper (over steel)



***Severely drawn pan** (top) shows no evidence of cracking of the Bakekote copper and brass film. A canister lid (bottom) shows good adhesion of the coating on a wrinkled flange.*



how Vacuum Metals FERROVAC solved critical surface problem for Bausch & Lomb . . .

The jewelers' rolls Bausch & Lomb use to roll gold-alloy wire for eyeglass frames must be *mirror-smooth*. Rolls of conventional air-melted alloys just didn't work out economically. A normal amount of nonmetallic inclusions in the metal meant they had to be ground and reground, polished and repolished, before the surface was satisfactory. And even then, many rolls had to be scrapped when finishing uncovered inclusion pits.

The solution to this problem proved to be Vacuum Metals FERROVAC® Airdi 150. A better finish was obtained without any regrinding—and the number of scrapped rolls fell to zero. Here's why: Vacuum-melting removes the gases which create nonmetallic inclusions in the molten metal before they get into the product. This means cleaner metal, smoother surfaces. What's more, vacuum-melting improves fatigue, creep and impact strengths . . . reduces brittleness.

Vacuum-melted metals are the answer to jobs where surface is critical—like gauge blocks, plug and ring gauges, rolls for aluminum foil—as well as many other specially demanding applications. They're available in most grades and sizes, including special ferrous and non-ferrous alloys. Write now for a free analysis sheet on which to describe your application. It will help us both decide how vacuum-melted metals can serve you best. *Vacuum Metals Corporation, Div. of Crucible Steel Company of America, P.O. Box 977, Syracuse 1, N.Y.*

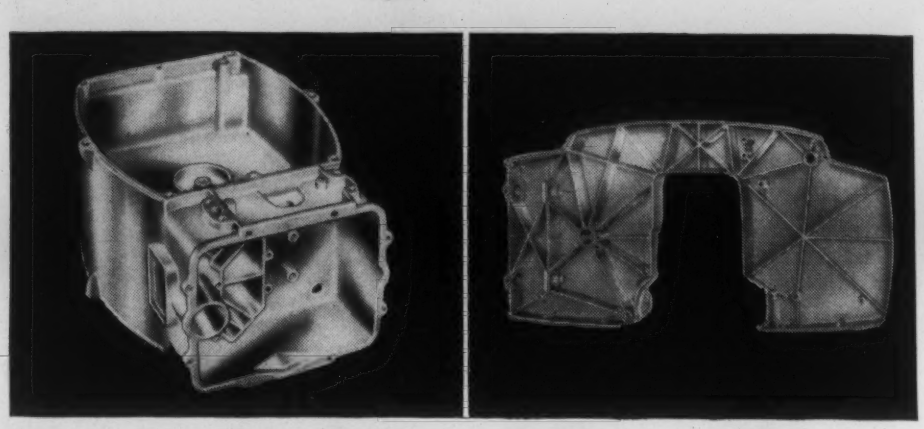
VMC®

VACUUM METALS CORPORATION

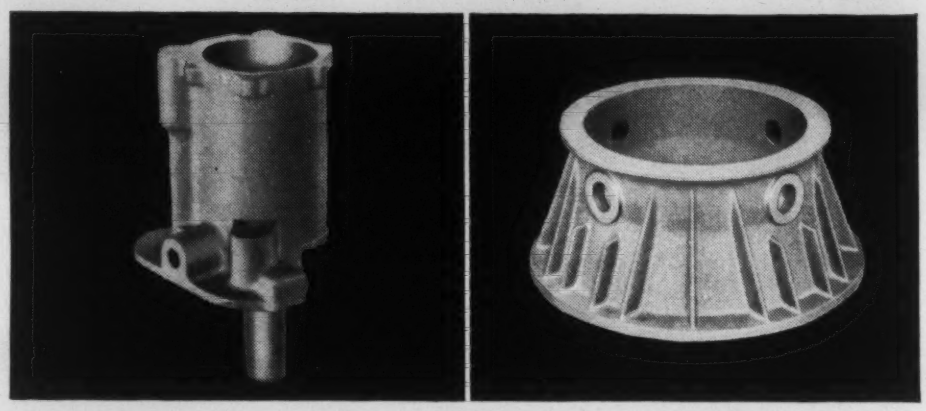
Division of Crucible Steel Company of America

For more information, turn to Reader Service Card, Circle No. 467

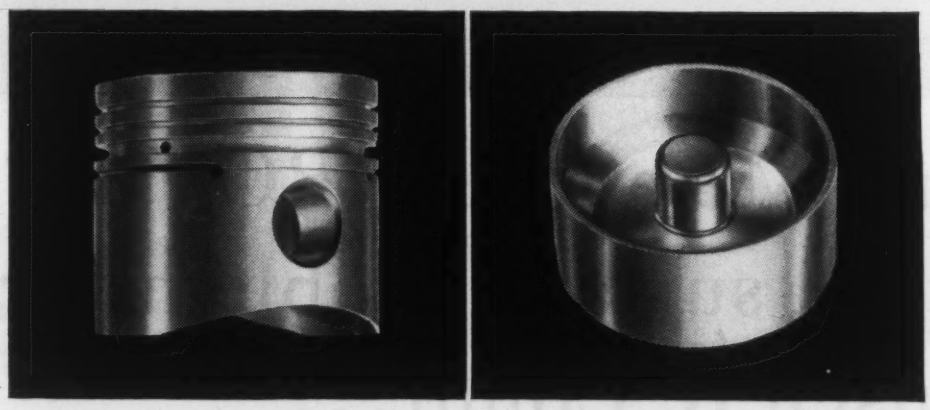
for die castings



...permanent mold castings



...impact extrusions



Regardless of your product, if you use castings or impact extrusions, Thompson's experienced and creative engineers can show you where and how to simplify your operations and save on costs. Let us quote now on your plans. Just write, wire or phone Dept. MM-2, Light Metals Division, Thompson Products, Inc., 2269 Ashland Road, Cleveland 3, Ohio, HEnderson 1-6765.

You can count on

Thompson Products

LIGHT METALS DIVISION

2269 Ashland Road • Cleveland 3, Ohio

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Industrial Distributors
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Cleveland 9, Ohio
SHadyside 9-0900

Stampress Engineering
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For more information, turn to Reader Service Card, Circle No. 390

What's new IN MATERIALS

showed that the film offered 80 to 90% better corrosion resistance than ordinary lacquer.

The Bakekote coated metals are recommended for door hardware, switch plates, light fixtures and other housewares.

Putty Repairs Rubber Without Heat, Molds

Vulcanized repairs to rubber wire insulation, conveyor belts, hose and floor coverings can now be made without using heat, pressure or molds, according to an announcement by *Patch Rubber Co.*, 884 W. Waterloo Rd., Akron, Ohio. Called Chem Rubber-Fix, a new repair material consists of two rubber-base putties that self vulcanize within 24 to 72 hr at room temperature. The material is also said to provide a bond between rubber and metal surfaces when used with special cements.

Having a shrinkage of less than 2%, the material can be hand molded to any permanent shape, thickness or contour, including gaskets and washers. When cured at room temperature, the repair material has a durometer hardness of about 48 and is said to have physical properties equaling those of a heat-vulcanized product.

Epoxy-Fiberglass Tube Is Porous, Resists Heat

A porous wall, fiberglass-epoxy tubing that withstands temperatures up to 350 F is available from *Lamtex Industries, Inc.*, 51 State St., Westbury, N. Y. The tubing is made in several degrees of accurately controlled porosity by varying the fiberglass weave, the epoxy formula and the impregnation procedure.

Designated Poro-Tube, the porous tubing is easily machined to close tolerances without shredding

TRADE-MARKS WHICH IDENTIFY THE ORIGINAL AND THE BEST

"PHOSPHOR BRONZE."®

®

Phosphor Bronze ®

ELEPHANT BRAND®

A little more than seventy-five years ago a wonderful new kind of copper and tin alloy possessing high tensile strength, great resiliency and unusual corrosion-resistant properties was introduced to American industry. This new bronze alloy had been perfected by the addition of a small amount of phosphorus to the copper and tin mixture.

No other producer of metals in the United States was able to duplicate this extraordinarily useful alloy. Therefore, because of the uniqueness of this new phosphorus-bearing *alloy*, the smelters responsible for its creation gave it a trade name "PHOSPHOR BRONZE" and adopted for itself the firm name of The Phosphor Bronze Smelting Company.

This was the first Phosphor Bronze ever produced in the United States of America.

"Phosphor Bronze" was immediately accepted by America's burgeoning industry. Demand for the new alloy grew by leaps and bounds and The Phosphor Bronze Smelting Company soon had many imitations of its products. So, to protect customers from spurious imitations, the trade name of "Phosphor Bronze" was incorporated into two distinctive *trade-marks* which were duly registered in the U. S. Patent Office on February 21, 1888. These trade-mark registrations have been maintained, in full force, throughout the intervening years and are presently owned by The Phosphor Bronze Corporation, successors to the original Phosphor Bronze Smelting Company.

In time, new variations of the original "Phosphor Bronze" alloy were introduced by the now-famous smelting Company. To identify these, the trade name of "ELEPHANT BRAND" was adopted, together with a distinctive picture of an elephant. The words "ELEPHANT BRAND" were incorporated into a *trade-mark* and registered with the U. S. Patent Office on August 20, 1907. The picture of the elephant shown in this advertisement, is a new one, designed to supersede its 1906 predecessor and was Registered, as a *trade-mark,* on October 2, 1956.

We are proud that American industry has wholeheartedly accepted our product. The name "PHOSPHOR BRONZE" has become internationally known and is familiar to metalworking men and metallurgists everywhere.

In view of this unanimous acceptance and usage, we—the officers, stockholders and employees of The Phosphor Bronze Corporation acknowledge the universal use of the name and herewith bequeath it to the American metalworking industries. We reserve only . . . the exclusive right to use the trade-marks illustrated above.

THE PHOSPHOR BRONZE CORPORATION

A Wholly Owned and Operated Subsidiary of The Seymour Manufacturing Company

SEYMOUR, CONNECTICUT

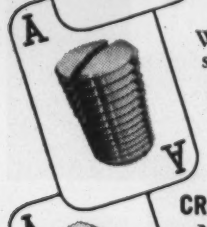
Full House!

...a setko self-locking set screw **for every problem!**

... And, every Setko Self-Locking set screw is an *ace* performer! Each one depends on a specific design principle to lock fast.

They provide positive locking action ... speed assembly and cut costs by utilizing standard driving techniques ... don't require special tapping. All are available in regular points, patented Nu-Cup point, and standard sizes and threads. With the Setko System, they can be hopper-fed in sizes as small as #2 (.086" x 1/8").

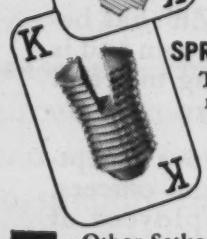
ZIP-GRIP® SET SCREWS
Exclusive Contra-Thrust action locks at any point. Solves problems of loosening due to wear, clearance in the thread, or vibration. Can be re-used.



OFFSET SET SCREWS
When driven, two offset edges in threaded portion exert powerful spring pressure. Not affected by extreme variations in tapped holes.

CREST-LOK SET SCREWS
New, original design doesn't require precise tapping. Can be re-used repeatedly. Amount of lock can be altered by changing tap drill size.

POINT-LOK SET SCREWS
This design ends top-screw loosening on two-screw applications. Lower screw can be locked with Point-Lok without disturbing original setting. Can be re-used.



SPRED-LOK® SET SCREWS
This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

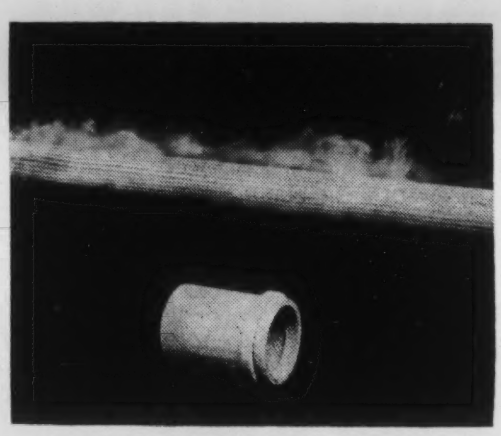
Other Setko Self-Locking set screws that solve specific problems include Flush-Lok, Wedge, Truncated and Jam-Lok. A complete description of Setko set screws including Nu-Cup and Self-Tapping, and the Setko System for hopper-feeding headless set screws is contained in Catalog 21. Write today for your free copy

Set Screw & Mfg. Co.
149 Main Street, Bartlett, Illinois

1583

For more information, Circle No. 460

What's new IN MATERIALS



Smoke test *illustrates porosity of Lamtex fiberglass-epoxy tubing.*

or unraveling, and is claimed to be impervious to most gases, fuels, oils and chemicals, including sulfuric acid, sodium hydroxide, copper plating solutions, ethylene glycol, hydraulic fluids and aircraft fuels.

The tubing is available in any cross section, including round, square, oval, rectangular, tapered and triangular, in lengths to 9 ft or greater, in any wall thickness down to 0.005 in., and in any diameter down to 0.062 in. i.d.

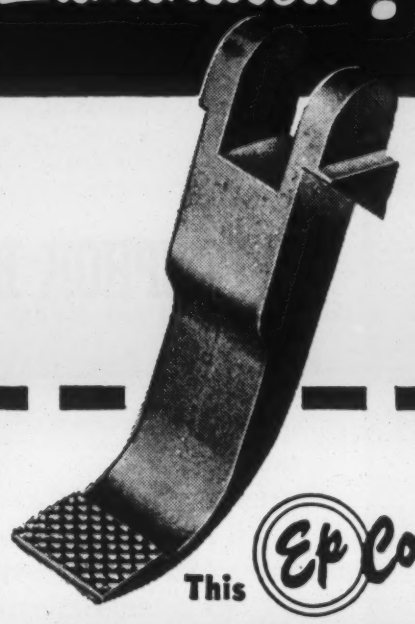
Featuring light weight (0.03 lb per cu in.), a good sealing and bonding surface, and dimensional stability, the tubing is recommended for such applications as potting and impregnating forms, nozzles and spacers.

Urethane Foam Rubber Has Adhesive Backing

Polyurethane foam rubber with a nonstretch, pressure sensitive adhesive coating is now available from *Durable Rubber Products Co.*, 609 West Lake St., Chicago, Ill. The foam rubber can be applied to any surface after the protective paper backing is removed. The adhesive coating is said to lower joining costs.

The foam material is available in continuous rolls of various sizes in a variety of colors. It is also die cut to specifications and fabricated in various shapes and forms.

FORGING, COINING and MILLING *Eliminated!*



This EPCo

INVESTMENT CASTING Proves the Point

PART: Paper Gripper for Printing Press

MATERIAL: Alloy Steel 4340

PROBLEM: To lower costs substantially below those of difficult and expensive forming methods yet retain the following features:

1. Sharp reverse knurling for more efficient gripper action.
2. Maintain uniform gripping action from part to part.
3. Eliminate milling and coining operations.

SOLUTION: An EPCO Investment Casting - - It produced a sharp gripping pad in true relationship to the center line of part.

CONCLUSION: When the shape of a part makes it difficult or expensive to perform special forming operations check an EPCO Investment Casting as a possible solution.

Send us drawings, samples and specification of parts for detailed process analysis and cost quotation without cost or obligation.

ENGINEERED PRECISION CASTING CO.
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MEMBER INVESTMENT CASTING INSTITUTE

For more information, Circle No. 520

when should you pay $13.00* a pound for TITANIUM?

The answer is *when its cost/life ratio makes titanium less costly than other metals*—as it often does. Look at it this way . . .

More Metal Per Pound—Titanium weighs only 56% as much as steel of the same strength. Where 50 pounds of steel is needed—28 pounds of titanium will do the job.

It's Final Cost That Counts—Fabricating takes the lion's share of production costs on most jobs. Considering material and fabricating costs together usually whittles down the titanium price differential to 2 or 3 to 1. And, most important . . .

Titanium Outlasts Most Metals—even those generally considered 'corrosion-resistant,' by 10, 20, even 50 times or more.

Added together, these facts often make titanium the most inexpensive material you can use. And only titanium can provide its exceptional combination of *light-weight, high-strength,* and *resistance to corrosion.* Ask a REM-CRU engineer to give you complete details about what titanium can do for you.

**The actual cost of titanium mill products varies with the grade, size and quantity ordered. The $13.00 figure is representative of today's prices for items used in commercial applications.*

Write Dept. M-2 for the Rem-Cru Review—a free periodical presenting the latest data on titanium.

REM-CRU TITANIUM

World's Most Versatile Metal

MIDLAND, PENNSYLVANIA

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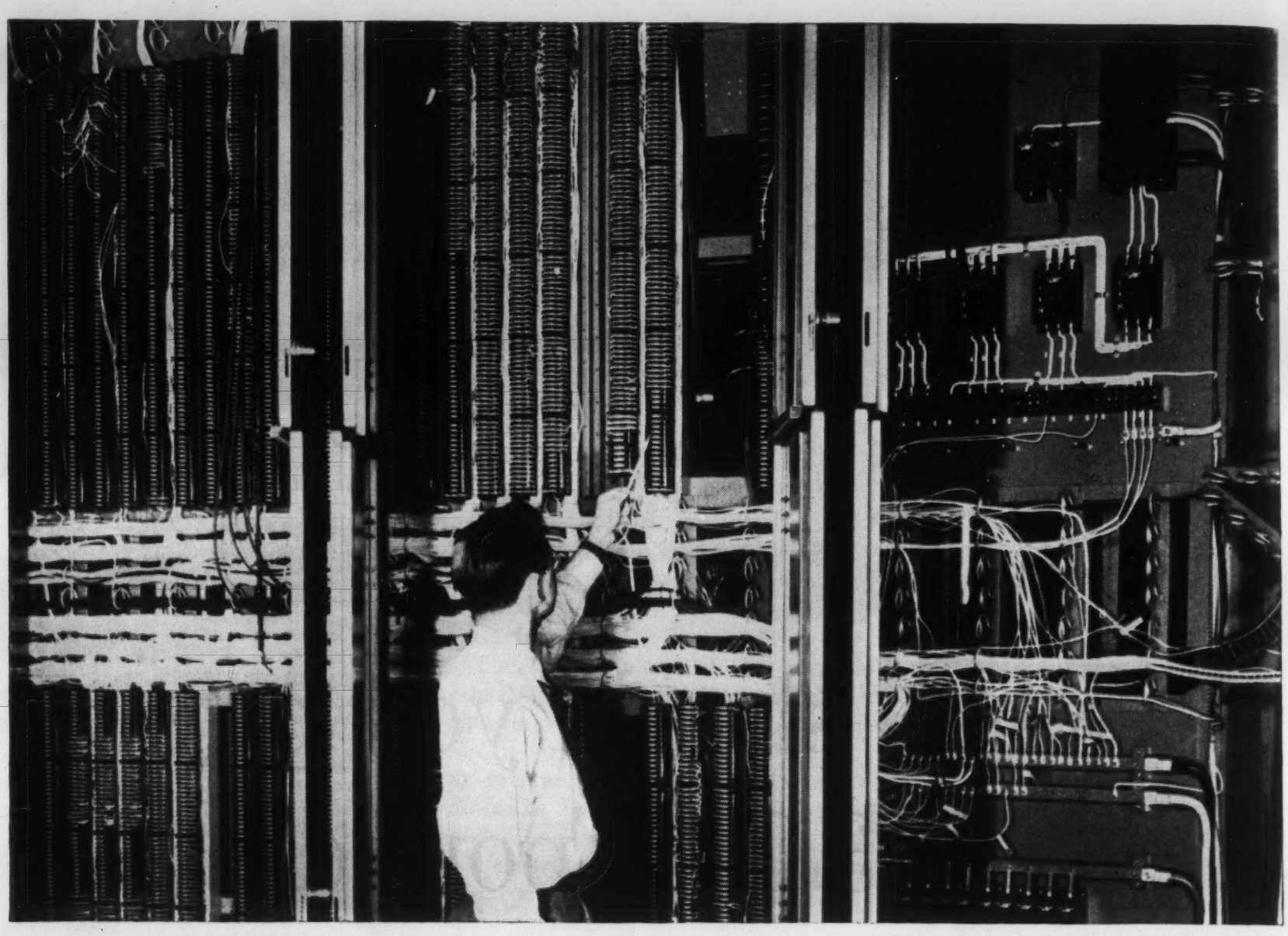
For more information, turn to Reader Service Card, Circle No. 533

When one of many requirements is

DIELECTRIC STRENGTH



. . . get the others too with DUREZ PHENOLICS

Among all materials the phenolics are unmatched for combining dielectric strength with other properties—electrical, thermal, and mechanical—required by many of today's engineered products.

It pays so often to turn first to the Durez phenolics because they are excellent self-insulators, having a high dielectric constant, low water absorption, and good power factor.

Due to their dimensional stability, Durez plastics are specified with confidence by engineers and recommended by molders for close-tolerance components. Impact strength and heat resistance are added major advantages in a wide range of applications.

To help your molder assure the results you want at lowest cost, many types of Durez permit easy preforming and molding in automatic machines. Talk your problem over with him... or let us send you engineering data.

At your service is the experience and engineering service that have made Durez the most widely used phenolics.

DUREZ®

Phenolic Plastics that Fit the Job

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

1402 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER® CHEMICALS PLASTICS

For more information, turn to Reader Service Card, Circle No. 428

PRICE$ AND SUPPLY

The Outlook by Herman B. Director, *Consultant, Washington, D. C.*

No more steel ingot means price rise certain

The government's decision to withhold assignment of "defense" preference ratings to the steel tanker programs is based on the fact that assignment of priorities to any one program for any product inevitably upsets all other steel products, as well as materials dependent upon steel. The solution which suggests itself is a broad base expansion beginning with the ingot. A sufficiency of ingot would permit greater flexibility in shifting from product to product by expansion or conversion of specialized facilities.

Although the government recognizes the dependence of product mobility on ingot availability, it has been unable to find a basis for facilitating expansion at the ingot level through a grant of rapid tax amortization. The stage has thus been set for an across-the-board price increase, as contrasted with the creeping price increase, of recent months via the "extras" route. The answer to the question of "when and how much" which we raised last month clearly is: soon and 7 to 9%, beginning with hard-to-get steel items.

Copper price may go down

Although copper economics continue to stump the experts, several things are clear: supplies are more than adequate; producers' and consumers' stocks are high; and demand, reasonably high at about 115,000 tons per month, is not as high as the 140,000 ton monthly average we had become accustomed to. Pressure on prices is downward, sparked by reductions in more sensitive foreign markets.

Nickel: higher prices, continued expansion

Primary nickel price increases will result in higher priced nickel-bearing steels as well as higher cost metal finishing. However, this increase is not likely to discourage continued expansion of nickel applications.

The shortage of nickel continues, especially in the face of the government's inability to carry out completely its diversion policies due to legal and contractual problems. Supplies will actually be less than anticipated.

Titanium sponge piles up

Producers of titanium have great confidence in the potential market; however, this market seems further removed than was actually anticipated at the time both industry and the government plowed over a billion dollars into the development of this metal. All excess titanium sponge goes into the government stocks, which are believed to be sizable. In spite of the large surpluses of titanium sponge, our agricultural barter program is reported to be bringing in 6000 tons of additional Japanese titanium sponge.

Titanium product prices continue to move down with prospects for still further downturns due to continued technological improvement and better scrap utilization techniques.

Tin supply back to normal

Tin supplies are ample with no price increase, imminent. The Suez situation has been overcome.

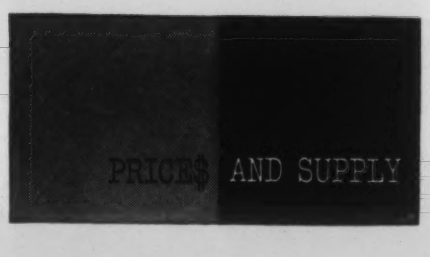
Silicon price cut

The high price of selenium stimulated and speeded up successful development of silicon for electronic uses. Current expansion in use of silicon is reflected in a recent $30 per lb price reduction. Prices of silicon rectifiers also have been reduced up to 17%. Although silicon sells at $320 per lb, it only takes about 80 lb of silicon to make 25,000 rectifiers—an average cost of about 10¢ per rectifier.

Larger supply of cobalt means lower prices

Cobat prices have been cut 25¢ per lb. Large scale additions to supply from North America, especially U. S. domestic sources, already well under way could mean additional price cuts in the not too far distant future.

(continued on p 230)



The Outlook—continued

Synthetic rubber: more at higher prices

Supply of synthetic rubber is scheduled for about a 10% increase; price increases are also expected.

Plastics: more at lower prices

The chemical industry continues to expand supplies of plastics, especially polyethylene (both high and low pressure types). Demand, presently at an all-time high, is still lagging far behind supply. Insofar as actual production is concerned, vinyl remains the largest volume item in the plastics group, followed by styrene and polyethylene. Competition and supply are all exerting downward pressures on prices.

Lots of paint for 1957

Use of paints and pigments is scheduled to increase, with supplies amply available at higher prices already in effect. Earlier shortages, such as existed in the first half of 1956, will not recur even when the highway program requiring tremendous quantities of paint gets going.

Synthetic fibers, woven fabrics cost more

The substantial increase in the price of synthetic fibers has forced an increase in the price of woven fabrics, including nylon, dacron and acetate filament yarn fabrics. This means higher costs to automotive, commercial and household goods manufacturers who have been leaning heavily on synthetic coverings.

Threat of competition cuts styrene prices

Styrene prices have been slashed by chemical companies to discourage synthetic rubber manufacturers from going into the styrene business. Rubber producers use large quantities of styrene in the manufacture of GR-S.

Congress and the lumber situation

Lumber and plywood are in greater demand and seem to have reached a turning point in both demand and price. Although facilities shut down as a result of the housing slump have not yet reopened, sustained demand for even a short period will bring them back into the picture. What Congress does to step up housing will have a lot to do with whether or not the industry steps up production.

How highway program will affect materials

The national highway building program, which has thus far slipped pretty badly, should begin to move along at an accelerated rate early this spring and on through the summer. This program will require a variety of materials in rather substantial tonnages, including many not normally thought of in connection with highway construction. In 1956, total highway construction approached $6 billion. Accelerating the program in order to achieve announced road construction goals would mean adding at least $2 billion of construction in 1957. Accomplishment of this goal would require substantially more materials than were consumed in 1956 highway construction in virtually all of the materials categories. For example, use of steel, lumber and metal pipe would be increased by more than 30%.

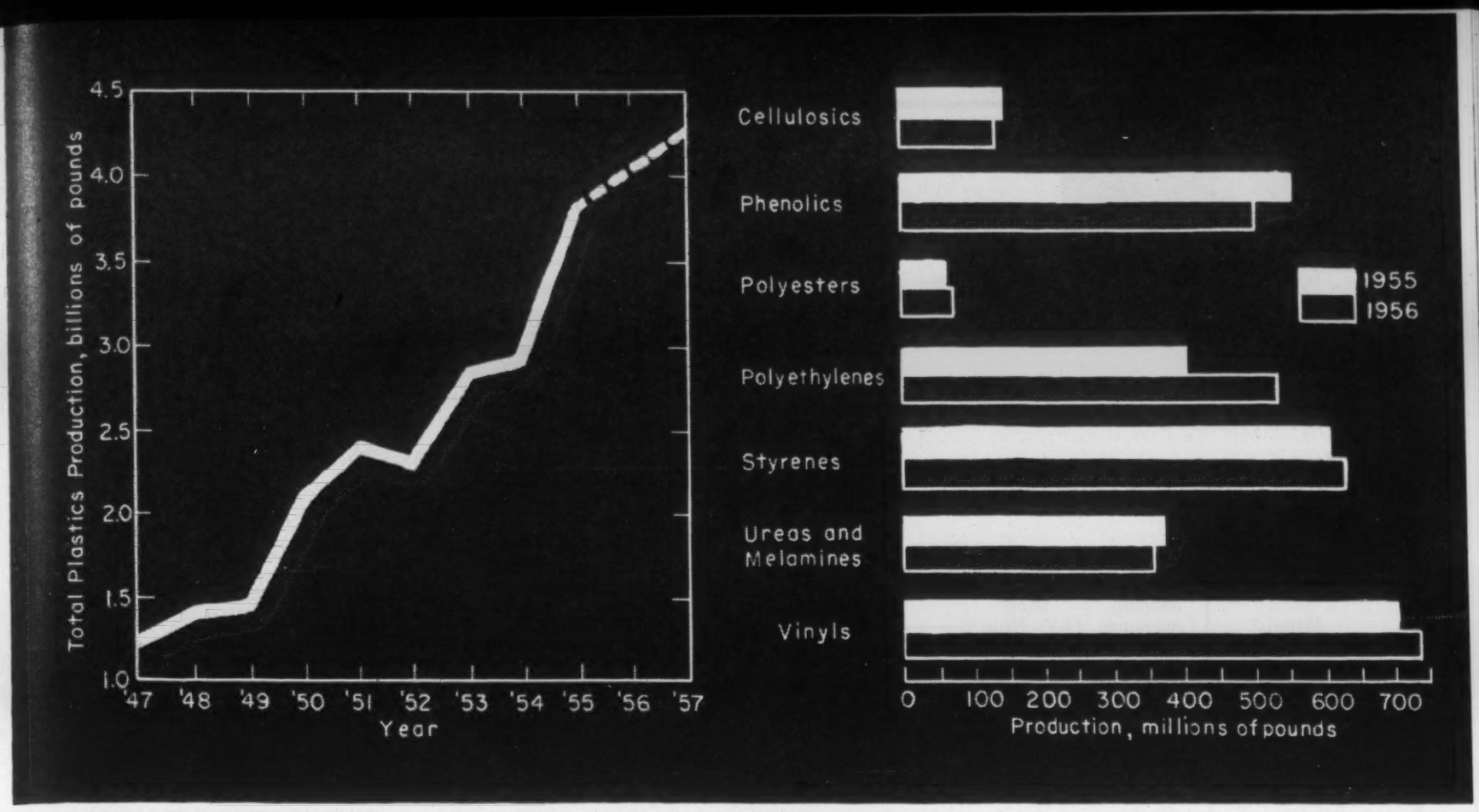
One of the most interesting aspects of the highway program is the impending competition among steel, aluminum and porcelain enamel highway signs and markers. This tremendous market should revive all of the comparative arguments regarding visibility, corrosion resistance and economy.

Stainless Market Picture is False

The amount of stainless consumed by the chemical market—mostly plate and tubing—is four times as large as thought. The same applies to stainless for restaurant and equipment use.

These facts were brought out by a recent survey to determine the ultimate destination of stainless steel first shipped to warehouses, a lot which amounts to 20% of total production. A special subcommittee of the American Iron & Steel Institute worked with American Steel Warehouse Assn. to conduct the survey and tabulate the results.

Perhaps the most significant fact was that the aircraft industry ends up with the largest portion of warehouse stainless.



***Production** of all plastics materials from 1947 to 1957. Figures for 1956-1957 are based on SPI estimates.*

***Comparison** between 1955 and 1956 production of some basic plastics.*

Plastics Use Up in '56 but Growth Easing Off

■ About 4,112,000,000 lb of plastics materials were consumed in this country in 1956, according to an estimate by the Society of the Plastics Industry. This figure not only represents a 10% increase over 1955, when production totaled almost 3,740,000,000 lb, but also the first time annual production has exceeded four billion pounds. Only ten years ago production was less than one billion pounds.

Except for the year 1952 and excluding cellulose plastics, production of plastics materials has risen steadily each year since 1947. On a straight line projection, it has been predicted that production in 1960 would exceed 8.5 billion pounds.

However, as Bryce Maxwell pointed out at the recent ASME meeting, such a prediction, based on a "rate of growth far in excess of our population growth is somewhat unrealistic. It cannot," he said, "continue forever."

A more meaningful estimate of future production, considering both market and sociological trends, places the 1960 production rate at about 7 billion pounds. At this time last year the best estimates placed 1960 production at 6 billion pounds, far below either of the current estimates.

Growth in the use of plastics has tended to level off. The SPI estimates only a 5% increase in consumption in 1957. What is more interesting, perhaps, is the fact that fewer and fewer new companies are coming into existence. "Mergers and consolidations between existing companies have continued at a rate which would indicate that in the future production of plastics materials will be centered in a rather small number of large companies," according to Mr. Maxwell. Over the last few years more than 65 major expansions in production facilities have been announced by plastics-producing companies.

As growth of the plastics industry tends to slow, a change in the emphasis of its research and development becomes apparent. In the past few years the emphasis has been not on producing entirely new materials, but rather on gaining a better understanding of polymers and on the modification and intelligent application of existing plastics. This trend will probably continue in the foreseeable future.

Lots More Nickel by 1960

By far the largest expansion will capacity may be of the order of 600-625 million pounds, or 175-200 million pounds more than the 427 million pounds produced in 1955. The increase will result from expansions by International Nickel Co. and other producers. By far the largest expansion will

(continued on p 236)

***Future** expansion of nickel use is forecast by existing prototypes of new aircraft. The experimental Bell X-2 shown here has stainless steel skins.*

Prices of Materials

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.46-.59
Butadiene-Styrene	.16-.30	.26-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural	.37	—

[a]Less than carload quantities.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
PTFCE	7-12	15-23	18-22		20-22.50	
PTFE	4.50-7.45	14.30-11	13		13	
Nylon	1.35-2.30	—	3		3	
Polyethylene	.37-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.27-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd, 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a, b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

a Price includes binder or finish.
b Price varies with binder.
c 0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	—	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

IRONS AND STEELS

Mill base prices for large quantities

STAINLESS STEELS ($/lb)

Material	Ingots	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic					
301, 302, 302B, 303, 304, 305	.21-.25	.36-.40	.41-.44	.45-.49	.50-.56
321	.28	.45	.50	.58	.63
347	.33	.54	.59	.67	.76
Martensitic					
410	.16	.27	.33	.34	.39
416	—	.28	.33	.35	.47
403	—	.31	.36	.39	.47
420, 440	—	.33	.40	44	.60
Ferritic					
405, 430, 430F	.16-.19	.28-.29	.33-.34	.35-.36	.39-.50
442	—	.32	.38	.40	.54
431	—	.36	.42	.44	.53
446	—	.38	.45	.46	.67
High Manganese					
202	.21	.35	.41	.43	.45
Extra-low Carbon					
304L	—	.44	.51	.53	.58
316L	—	.64	.74	.78	.82
Precip Hardenable					
17-7PH	—	.55	.65	.72	.77-.82

IRON ($/gross ton)

Pig	62.50-63.50

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	74
Billets, Blooms, Slabs	
Carbon, Re-rolling	74
Carbon, Forging	92
Alloy, Forging	107
Seamless Tube Rounds	112
Wire Rods	$5.85/cwt

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	4.85	7.25	6.85
Sheet, H.R.	4.70	6.90	—
Sheet, C.R.	5.75	8.50	—
Strip, H.R.	4.67	6.95	7.75
Strip, C.R.	6.85	10	14.55
Bar, H.R.	5.05	7.40	6.10
Bar, C.F.	6.85	—	8.30

All prices are approximate and given solely for the general guidance of those responsible for materials selection.

(Prices continued on p 234)

PRICE$ AND SUPPLY

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	9.70-9.95
Elec (0.25-0.75 lb)	8.40-9.15
Black Plate	7.50-7.60

METAL POWDERS ($/lb)[a]

Sponge Iron	.09-.10
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.34
Stainless Steel	
302	1.05
316	1.40

[a]Price for —100 mesh.

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where otherwise indicated.

ALUMINUM

Pig (99-99.9%)	.25-.27
Ingot (99-99.9%)	.27-.29
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-.03 in.)[a]	.40-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a]Mill finish.

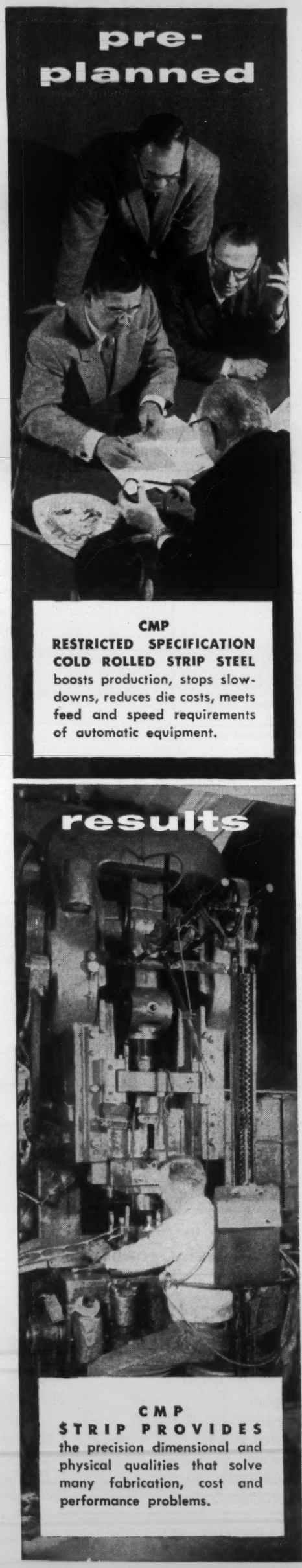
BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.50	.53	.55
Seamless Tubing	.53	.56	.57
Rod (not f.c.)	.50	.53	.55
Wire	.51	.54	.55

COPPER

Ingot (elec)	.36
Sheet, Strip (hot rolled)	.58
Seamless Tubing	.58
Rod, Drawn	.55
Rod, Free Cutting	.64
Wire	
Round	.41
Square, Rectangular	.45
Magnet	.49

(Prices continued on p 234)



In estimating production costs, one of the items a metal fabricator takes into account is the cost of steel. As important as this is, it is sometimes good economics to pay more for steel, but pay less in the end for the fabricated part. The cost of down time on expensive forming equipment, the cost of idle labor, the cost of re-processing defective parts, may well exceed the cost of the extras built into restricted specification steel, which will eliminate these unplanned-for costs.

CMP restricted specification cold rolled strip steel can be pre-planned to minimize production delays and produce for you the production cost you need. We will welcome the opportunity to explore with you the cost-saving potentials in your manufacturing processes which may be available to you by use of **CMP** restricted specification cold rolled strip steel.

CMP

WHERE YOU CAN GET SPECIFIC SPECS FOR SPECIFIC JOBS

LOW CARBON, ELECTRO ZINC COATED, HIGH CARBON, TEMPERED SPRING STEEL, STAINLESS AND ALLOY

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For more information, turn to Reader Service Card, Circle No. 504

STRAITS TIN REPORT

New developments in the production, marketing and uses of tin

MALAYAN TIN BUREAU

The largest tin-producing country in the world is the Federation of Malaya. It mines the most ore. It produces and exports the most tin metal. In 1955, for instance, Malaya supplied nearly 75% of U.S. imports of pig tin. One of the most significant facts about Malaya's tin reserves is that less than 2% of the Federation's area has been set aside for tin mining.

★ ★ ★

The Malayan Tin Bureau in Washington was established by the tin producers of Malaya to provide accurate information about Straits Tin, one of the world's most useful metals. "Straits Tin Report," to be published at frequent intervals, will be factual and informative, helpful and interesting.

★ ★ ★

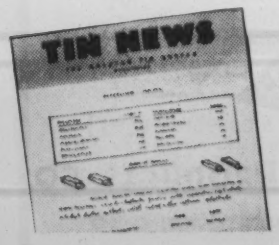
From A for aluminum to Z for zinc (and zirconium) tin is now being successfully alloyed for industrial applications with most other metals. Tin imparts properties to alloys obtainable from no other element.

★ ★ ★

New 20% tin-aluminum is a bearing metal with several times the fatigue strength of babbitt at working temperatures, and excellent antifriction properties. It is now producing outstanding results in actual performance tests.

★ ★ ★

Tin-zinc is a plating alloy which — thickness for thickness — gives greater protection against corrosion than either zinc or cadmium alone. And an alloy of tin and zirconium shows great practicability for water-cooled nuclear reactors.



Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau

Dept. 24B, 1028 Connecticut Ave., Washington 6, D.C.

For more information, Circle No. 514

PRICE$ AND SUPPLY

LEAD

Common Grade	.16

MAGNESIUM

Pig (98.8%)	.36
Ingot (98.8%)	.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN

Primary[a]	1.09

[a]Delivered price.

TITANIUM

Sponge (99.3+%)	2.50-2.75
Bars, Rod	7.10-7.35
Plate	9.25-11.25
Sheet, Strip	11.40-12.10
Wire	8.50-9.00

ZINC

Primary[a]	.13-.14[c]
Die Casting Alloys[b]	.18-.19[c]
Sheet	.24
Ribbon	.22

[a]Prime Western—Special High Grade.
[b]Alloys 2, 3, 5. [c]Delivered price.

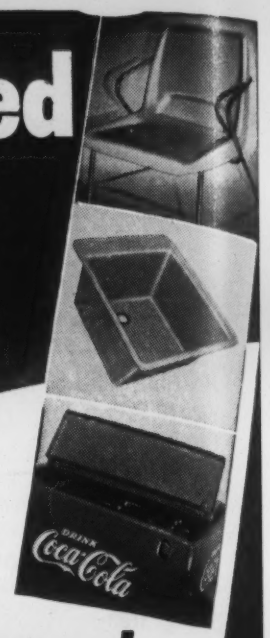
METAL POWDERS

Aluminum[a,b]	.36
Brass[a]	.37-.47
Copper (el or red.)[a]	.50
Columbium	120
Molybdenum (98%)	3.80-4.10
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4.20-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a]Price for −100 mesh. [c]Delivered price.
[b]Freight allowed.

(Prices continued on p 236)

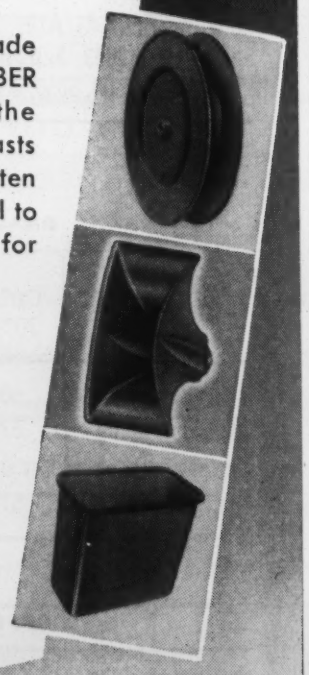
Molded Fiber Glass adds Sales Appeal to your product



MOLDED FIBER GLASS gives your product a unique combination of selling features that no other material can offer:

- Unusual strength
- Light weight
- Corrosion, rust and weather resistance
- Heat resistance
- Impact resistance
- Dielectric strength
- Molded-in color
- Beauty

Your product, made of MOLDED FIBER GLASS, does the job *better* . . . lasts longer . . . is often more economical to produce. Write for information.



The Molded Fiber Glass Companies are the world's largest producers of fiberglass reinforced plastic mass-produced in matched metal dies.

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For more information, Circle No. 419

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Only your *imagination* limits the ways you can use Ampco Alloys

That . . . and the requirements of the part you're designing

Should your part be sand-cast, centrifugally cast, shell-molded, precision-cast, forged, fabricated or extruded?

Let an Ampco field engineer help you to select the best, most economical form of production. It's all part of Ampco's one-source service to industry

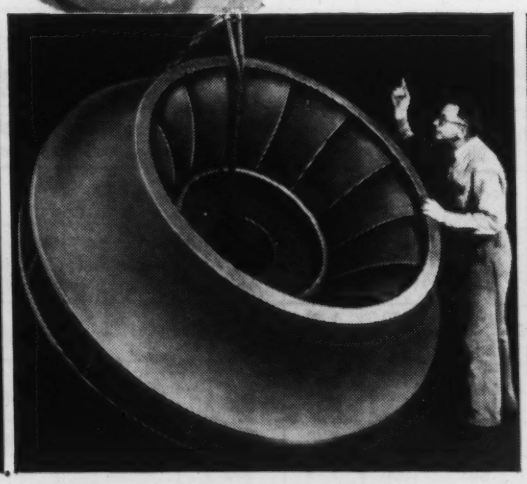
And he can help you select the best alloy, too. For among more than 100 Ampco copper-base alloys is the one you need to do the job — to resist wear, corrosion, impact, fatigue — to provide excellent bearing qualities — to retain physical characteristics at temperatures from 600°F down to −400°F.

So call in your Ampco field engineer and get his unbiased recommendations.

D-53

Write for Bulletin 33.

5,400-lb. centrifugal casting for flywheel of a marine engine. Ampco makes centrifugal castings from a few pounds to five tons.



12,000-lb. sand-cast water wheel. Ampco's sand foundry makes any-size casting to 14,000 pounds — sand, shell moldings, cast-to-size, cement.

Ampco's one-source service includes production-run machining of Ampco copper-base alloys to the exacting quality standards of the aircraft industry.

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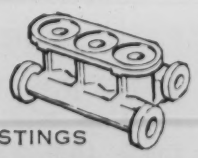

SAND CASTINGS

SHELL-MOLDED CASTINGS

CENTRIFUGAL CASTINGS

EXTRUSIONS

FABRICATIONS

SHEET AND PLATE

CAST-TO-SIZE CASTINGS

FORGINGS

MACHINED PARTS

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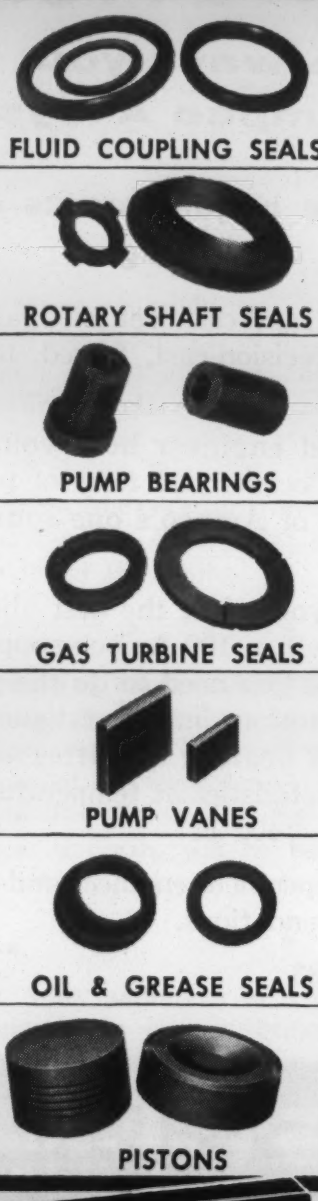

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COST
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Special grades are constantly being developed to meet specific requirements.

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CARBON GRADES FOR MECHANICAL APPLICATIONS

Grade	Hardness	Strength	Apparent Density	Max. Safe Oper. Temp. ° F	Typical Applications
SK 16	45	6000	1.75	250	Water Pumps
SK 182	70	8000	1.77	350	
SK 180	80	7000	1.75	650	Corrosive Chemicals
469	80	8000	1.80	1200	High speed, High Temperature Aircraft
SK 145	90	8000	1.80	800	
SK 187	80	9000	1.79	650	High Altitude Bearings
SK 188	65	7000	1.78	650	
SK 152	100	10000	1.75	650	Very hard material for bearings operating in liquid
SK 154	100	10000	1.75	650	
SK 157	75	7000	1.80	250	Appliance Seals
SK 176	80	7000	1.80	650	
SK 105	75	7000	1.60	500	Oil Seals
SK 175	75	7000	1.75	500	
304	80	9000	1.79	650	Vanes & Bearings
331	50	7000	1.74	800	Turbine Rings
P87	70	6000	1.68	650	
Y20	40	3000	1.65	650	
SK 21	45	7000	2.70	250	
SK 87	70	7000	1.77	250	
SK 201	50	7000	1.79	800	
378	65	8000	1.78	650	
G560	45	4500	1.68	800	
HB1	35	3000	1.58	800	
HB1-4	30	4000	1.68	800	

NEW
High Temperature Carbon

Thanks to a new Stackpole material, bearings and seals used in gas turbines and other high temperature applications show minimum oxidation at temperatures up to 1200°F compared to the usual limit of 800°F for non-treated materials.

STACKPOLE

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

For more information, turn to Reader Service Card, Circle No. 401

PRICE$ AND SUPPLY

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97 +%)	$2.25/troy oz
Manganese (99.9%)	.33[a]
Palladium	$23-24/troy oz
Platinum	$98-101/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a]Delivered price.

(continued from p 231)

be in Northern Manitoba where Inco plans a $175 million project.

This project, together with the progress under way at Sudbury, Ont., will lift Inco's annual nickel producing capacity by 50% over that of 1955, or from about 260 million to 385 million pounds. The new project will be the largest nickel producing operation in the world next to Inco's operations in the Sudbury district.

"With the achievement of this world capacity," Inco President Henry S. Wingate says, "the total free world capacity for nickel supplies should exceed the entire free world civilian consumption of nickel during the 12 months ended Sept 30, 1956, by more than 325 million pounds."

Simultaneously with this announcement, however, came news of an increase in the price of nickel. A 9½¢ per lb increase, the largest single advance for the metal, brings the price of electrolytic refined nickel to 74¢ per lb. Similar changes in price were announced for other forms of primary nickel. Corresponding increases were announced for nickel and nickel alloys in mill forms and castings.

(more News on p 238)

CORRECTION

In our Nov '56 article on "Fabricating Mechanical Steel Tubing", the sketches illustrating tubing with 45-deg and 90-deg flanges (p 126), respectively, were inadvertently transposed.

Fasten it with STAINLESS STEEL *for Better Looks—Longer Life*

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A complete line of stainless steel fasteners—all types and sizes of bolts and nuts, rivets, wood and machine screws, cotter pins, washers, etc.—are made of AL Stainless Steel by the leading manufacturers in this field. Get in touch with them for catalogs and prices, or write us direct.

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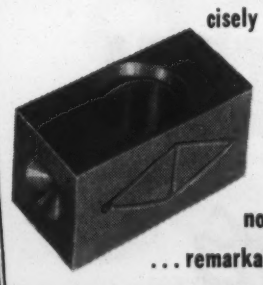
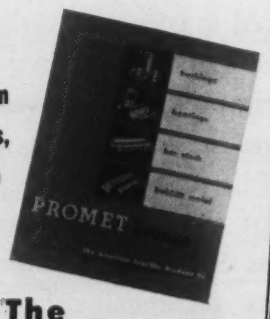


SEND PRINTS and condition of operation for recommendations, quotations, literature and service data sheets.



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[redacted] AND SUPPLY

Mercury and Antimony from Alaskan Ores

An economical method for recovering mercury and antimony from Alaskan ores may be the outcome of successful laboratory tests by the Bureau of Mines.

When mercury and antimony occur together, the antimony not only interferes with recovery of the mercury by standard methods but is itself lost. Alternative methods tested by the Bureau included gravity separation, bulk flotation of mercury and antimony sulfides, differential flotation, leaching, and furnacing of both crude ore and flotation concentrates.

The final reports stated that bulk flotation of sulfides followed by furnacing of the flotation concentrate with carefully regulated admission of air to the furnace recovered more than 95% of the mercury in Red Devil ore and made possible recovery of antimony from the furnace calcine. The metallurgists believe antimony recovery might run as high as 68%. Other tests indicated that leaching the ore or concentrates with sodium sulfide solution may yield separate mercury and antimony products.

Zirconium Recovery To Be Investigated

Electrorefining of zirconium will be studied by the Bureau of Mines in a $110,000 research project financed by the AEC.

The study will be aimed at developing a method for recovering valuable zirconium from impure sponge metal, mill scrap and zirconium alloys.

At present, only a small part of the impure sponge frequently obtained in making zirconium, and the scrap produced in fabricating and machining it, can be recycled to make reactor-grade material. Electrorefining promises to overcome this problem, according to

Stuck on Your Plastics Molder?

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But if you feel that you are stuck with your present plastics molder, it's time to turn to K & J for the service you have a right to expect and the top value from your molding dollar. Get the full story in our brochure, "A Service to Users of Compression Molded Plastics".

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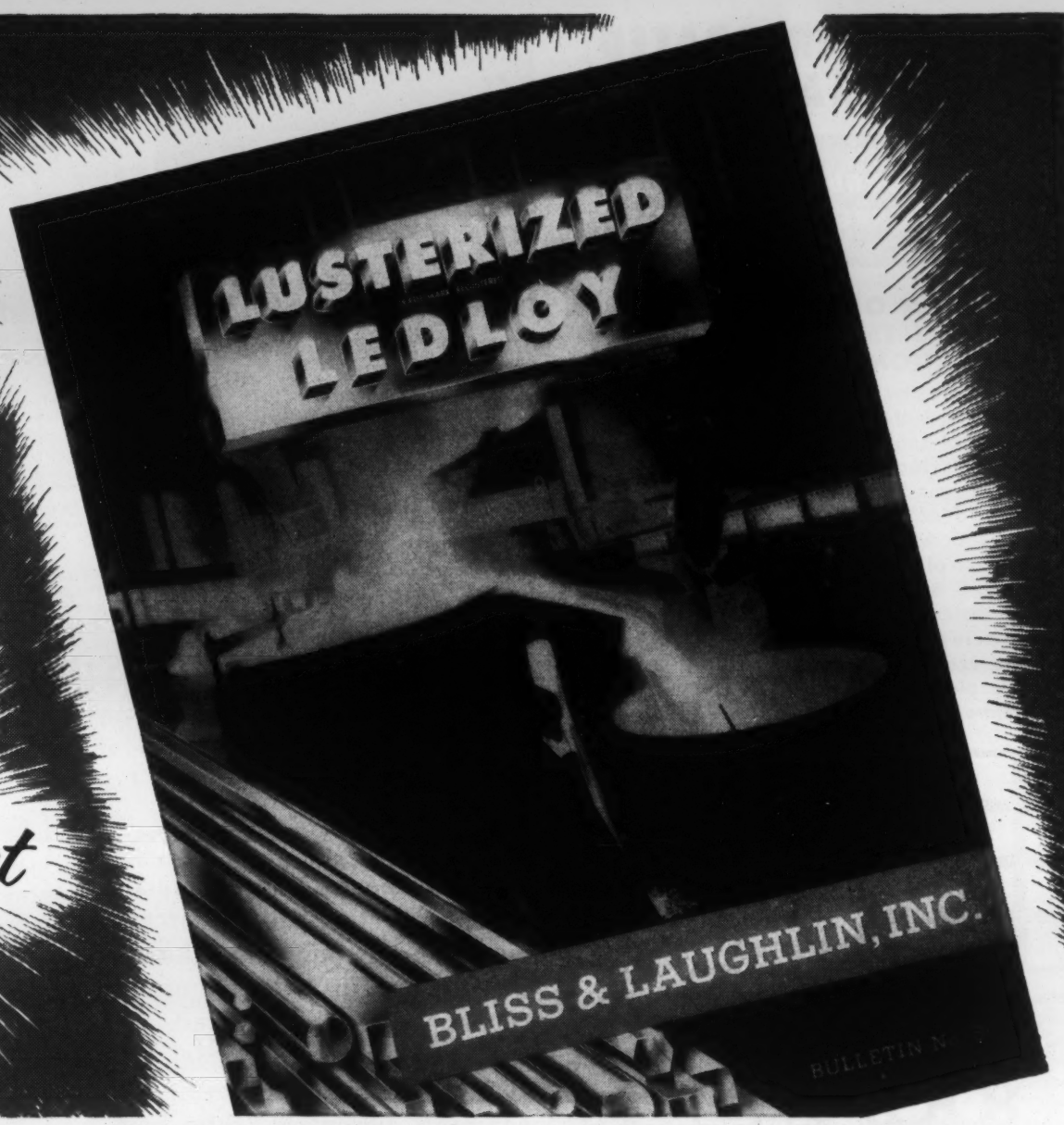

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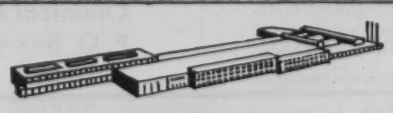
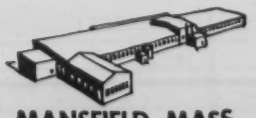

HARVEY, ILL.

DETROIT, MICH.

BUFFALO, N. Y.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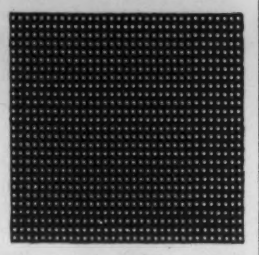
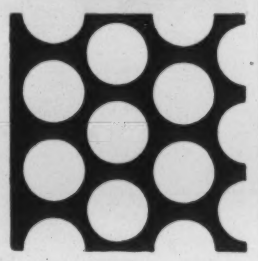
H&K PERFORATED MATERIALS

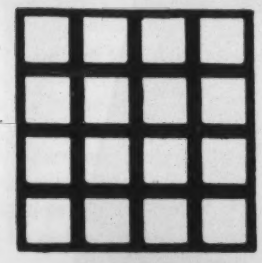
Utility · Beauty · Economy
FOR TOMORROW'S PRODUCTS

A *MEDIUM* OF LIMITLESS APPLICATIONS

Designers are discovering an ever-increasing range of applications for perforated materials. For functional or decorative purposes, or where a combination of both is essential, H & K perforated materials are used in more products, in more accessories, in more places than ever before.







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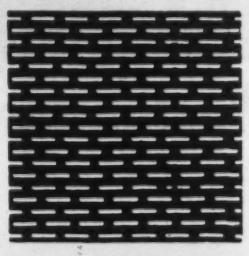

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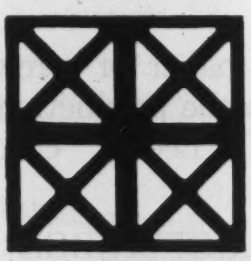
H & K engineers will be pleased to work with you on your requirements.



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For more information, Circle No. 502

[redacted] AND SUPPLY

Bureau of Mines Director Marling J. Ankeny. Various grades of scrap, offgrade sponge and certain zirconium alloys are fed into an electrolytic cell. When electric current is passed through the cell, the feed metal is dissolved and relatively pure zirconium is deposited on the cathode.

Metallurgists at the Boulder City station in Nevada will use techniques developed in the Bureau's pioneering research on electrorefining of titanium metal to guide them in designing the electrolytic cell for zirconium recovery.

"Development of a commercially feasible electrorefining process would make zirconium metal available for use in building atomic reactors," Mr. Ankeny said. "It would also recover material now lost in producing, fabricating and machining zirconium, thus helping to lower the metal's price and paving the way for its eventual use in other fields."

What's Happening in Prices and Supply

Aluminum—Two important expansion programs were announced at the end of the year. Aluminum Co. of America outlined a plan involving possible capital expenditure of about $600 million over a five year period extending through 1960. Ground was broken in 1956 for a major alumina plant at Point Comfort, Tex., and construction is presently under way. Two potlines were added to smelting facilities and construction was started on a 150,000-ton smelting plant near Evansville, Ind. Alcoa also expects to start construction on a new die casting plant near Metuchen, N. J., before the end of 1957.

The second major expansion was announced by Federated Metals Div. of American Smelting and Refining Co., which began

installation on tank truck interior shows how to

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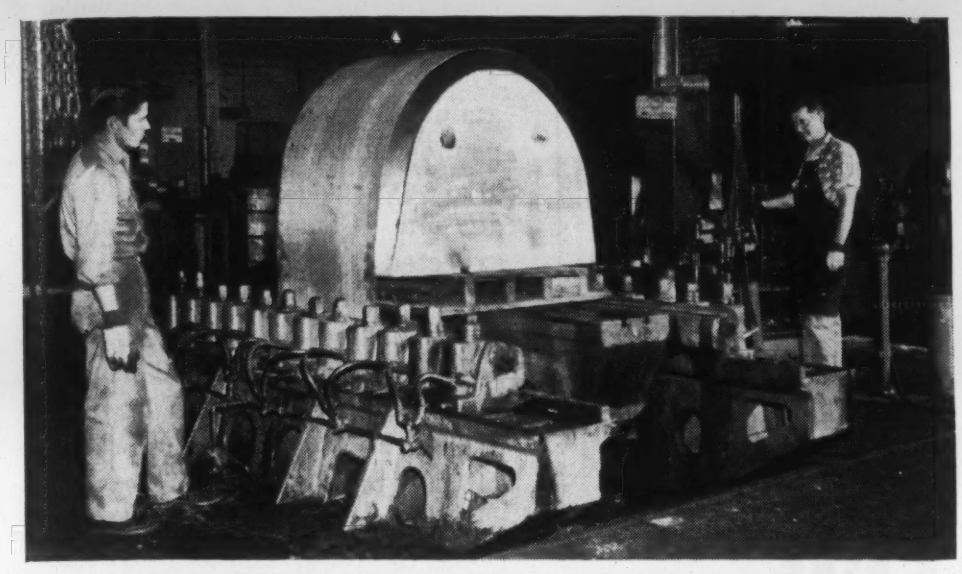
Progress with **TITANIUM**

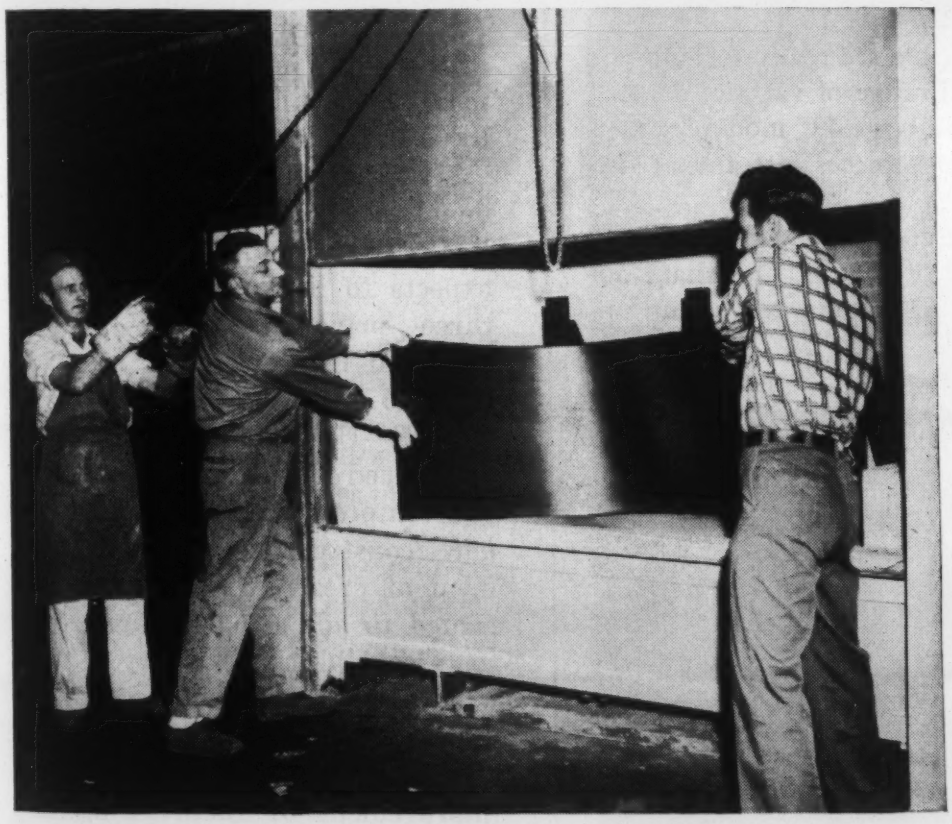
"In titanium stretch-forming, Mallory-Sharon material most consistent we have tried; simplifies fabrication"



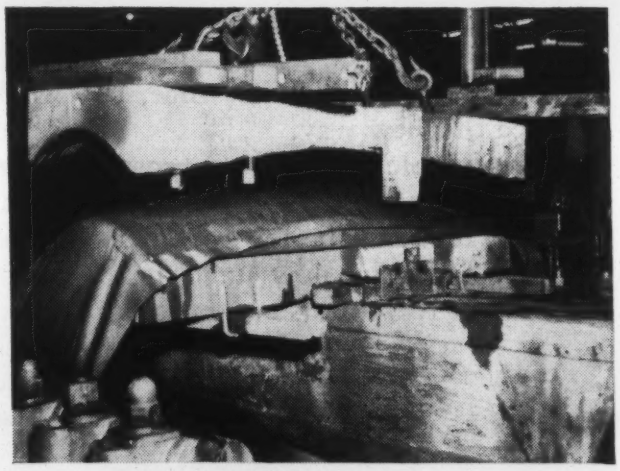
1. Initial forming *of titanium sheet at Hart Metal for jet engine pod. Since Mallory-Sharon titanium is certified in a definite strength range, springback is predictable, and allowed for in dies.*

. . . reports Hart Metal Products

● Because of titanium's springback characteristics, uniformity is particularly important in simplifying forming. Here, Mallory-Sharon sheet is preferred material for its consistent properties, the result of strict quality control. Each heat of Mallory-Sharon commercially pure titanium is certified for average strength and limits. For dependable quality, call us for your requirements, and for technical help in application.



2. Formed sheet *is annealed to relieve stress. With sheet material in a consistent strength range, Hart Metal reports that two or three stress relieving operations are eliminated.*



3. Double contour *produced by stretch-forming. Heated dies aid in obtaining desired shape with minimum number of operations.*

4. Formed skins are *checked in fixture and given final inspection. Fabricator reports very low scrap loss with uniform strength material.*

MALLORY Ti SHARON

MALLORY-SHARON TITANIUM CORPORATION · NILES, OHIO

Producers of titanium and titanium alloy sheet, strip, plate, rod, bar, billets

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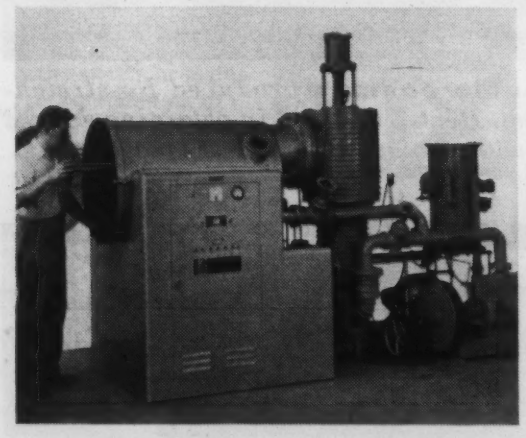
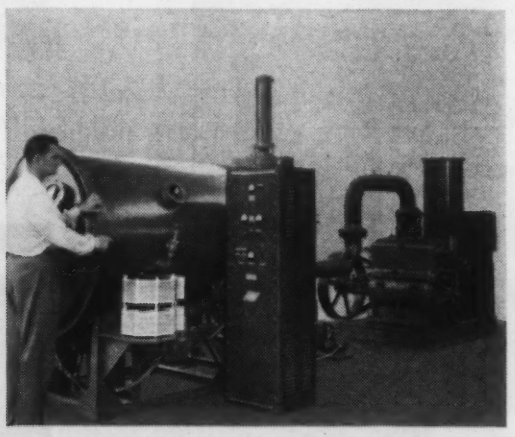
Vacuum metallizing is sure to grow rapidly. New business is waiting for you.

At CEC, we are ready to help you with a full range of vacuum coaters, headed by a large 48″ model for metallizing large pieces fast and at low cost.

We'll be glad to send you bulletins on our line of coaters, and share our experience in helping you set up operations.



30″ coater—model LC1-30
Typical production: 400 1½″ diameter pieces per cycle; 5 to 7 cycles per hour.



48″ coater—model LC1-48C
Typical production: 1450 2½″ diameter pieces per cycle; 3 to 6 cycles per hour.

Smaller coaters are available for production coating of optics or other small parts, and for laboratory and pilot plant work.

Consolidated Electrodynamics
Rochester Division, Rochester 3, N. Y.
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construction of a large secondary aluminum smelter at Alton, Ill. The new plant will have a rated annual capacity of 72 million pounds and will double Federated's present aluminum alloy production. Capacity production is expected by the spring of 1958. At that time, according to Frederick Walker, vice president, Federated will be the world's largest smelter of secondary aluminum.

Lead, zinc—Although more than 240,000 tons of zinc die castings were used in automotive applications in 1955, chances are that even more will be used in 1957 if . . . "as many cars are made in 1957 as in 1955." John L. Kimberley, executive vice president of American Zinc Institute, says the average 1957 model car will carry more than 65 lb of zinc, compared to 60 lb in 1956 and 50 lb in 1955.

H. Danforth Starr, vice president and treasurer of Cerro de Pasco Corp., indicates that Cerro expects to increase output of its three principal metals—copper, zinc and lead—as much as 45% by 1959.

Steel—U. S. Steel Corp. has announced plans for two large expansion programs. In Pittsburgh, new construction and improvement of present facilities are expected to add 670,000 ingot tons to steel-making capacity. This will raise the annual capacity of Monongahela Valley plants to about 11,910,000 tons. In Chicago, improvement of facilities is expected to add over 1,300,000 ingot tons. Plates and structural steel, now in short supply, will share the bulk of the additional 900,000 tons of steel products resulting from the ingot increase, according to Harvey B. Jordan, executive vice president. Work on both projects is expected to get under way early in 1957.

Meanwhile, steel prices are increasing. Many plants have raised base prices and practically all have increased "extras." Sharon

PRICE$ AND SUPPLY

Steel Corp., for example, announced increases of approximately 2¾% for hot rolled sheet and strip. So far, major producers have increased only "extras" and nickel-bearing alloys, but industry sources indicate general increases soon.

Titanium—Price reductions of 6-8% for titanium mill products were announced by Titanium Metals Corp. of America early in December. Since then, Du Pont has announced reductions of up to 25¢ per lb on its titanium metal sponge, bringing the price of top-grade sponge to $2.75 per lb. When first introduced by Du Pont in 1948, titanium sponge sold for $5.00 per lb.

Allied Chemical & Dye Corp. and Kennecott Copper Corp. have announced plans to form a new company to produce and sell titanium metal. It will have an initial investment of $40 million, and is expected to start producing sponge and billets late in 1958. Figures on production capacity have not been released. The new producer will use a method developed by Allied's Solvay Process Div., which is expected to be more economical than present techniques.

Synthetic rubber — Effective July 1, major producers will cut the price of styrene used in synthetic rubber to 12¢ per lb. Present price is 16¢. The cut followed reports that large rubber producers intended to build their own styrene plants.

Synthetic rubber output in this country topped one million tons last year, according to Harvey S. Firestone, Jr., president of Firestone Tire and Rubber Co. Previous high was 970,000 tons in 1955. A great part of this rubber went into the 104 million tires produced for the automotive industry. E. J. Thomas, president of Goodyear Tire and Rubber Co., estimates that 111 million tires will be made in 1957.

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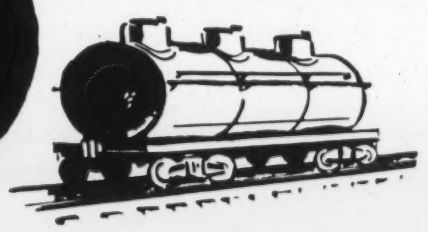

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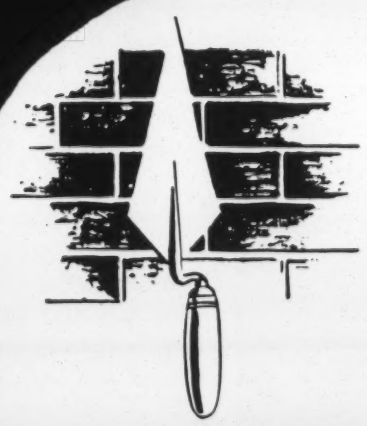

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For complete facts write for Bulletin CC-3.

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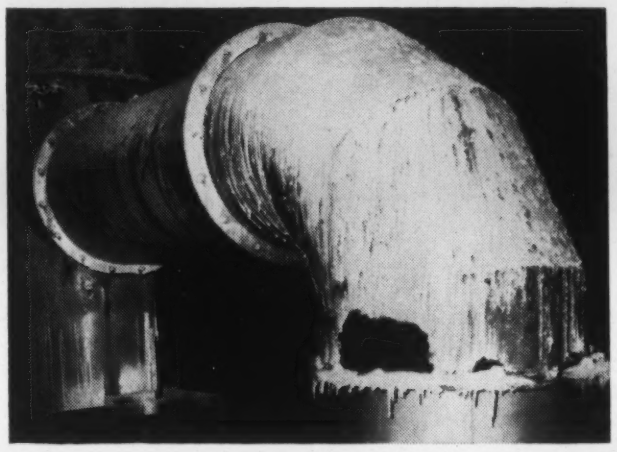
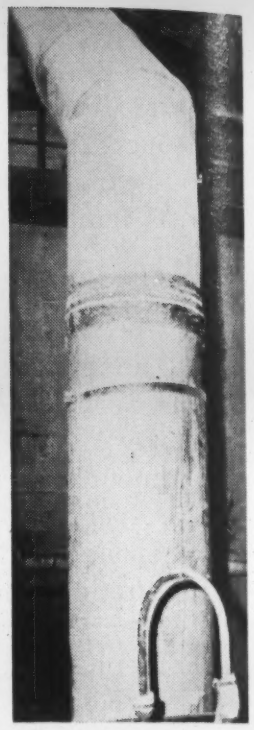
CYANAMID

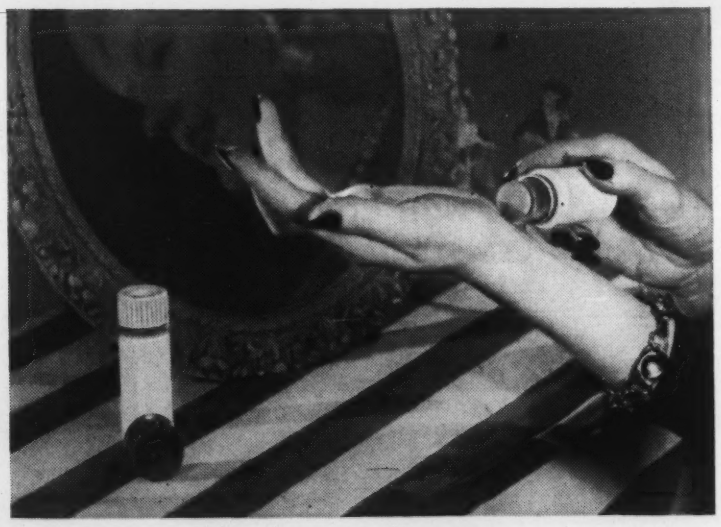
PLASTICS NEWSFRONT

THREE YEARS IN CORROSIVE SERVICE WITHOUT MAINTENANCE

That's the record established by reinforced LAMINAC® polyester resin in venting service on alum digesters at Cyanamid's Warners plant. The carbon steel breech (left) in an alum evaporator required frequent maintenance, failed after less than three year's service. Glass-reinforced LAMINAC stacks (right) in even more severe alum digester service, have needed no maintenance in more than three years. The LAMINAC units cost less in the long run, and were easier to erect and assemble, using either telescope joints wrapped and polyester-welded on the site, or flange-type joints.







ATTRACTIVE, AIRTIGHT CASE FOR STICK COLOGNE

Six new scents of Avon Stick Cologne are packaged in smartly styled, practical cases molded of BEETLE® urea molding compound. Cases have a white base with contrasting closures in a different color for each scent. Airtight, the BEETLE case stops evaporation of the cologne. Yet the closure opens easily, and with a twist of the wrist the stick pops up for use. The case resists alcohol, essential oils and chemicals as well as staining from perspiration and grime, which wipe off easily.

FUNCTIONAL HANDLES GRACE CARAFES

Any dining or buffet table would be graced by this attractive carafe with its stylish, beige-colored handle molded of CYMEL* melamine molding compound. Elegance and function are combined in the handle, balanced for easy, comfortable pouring. Harmonizing with the carafe's gold decoration, the molded-in color won't chip or wear off. In keeping with its function, CYMEL is exceptionally strong, resistant to heat and flame, and stays cool even when the carafe, made by Club Aluminum Products Company, is full of hot coffee.

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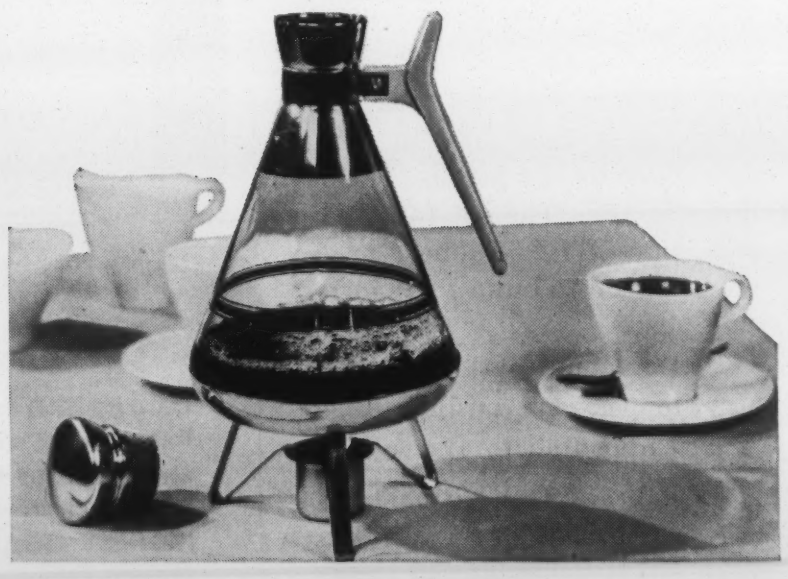

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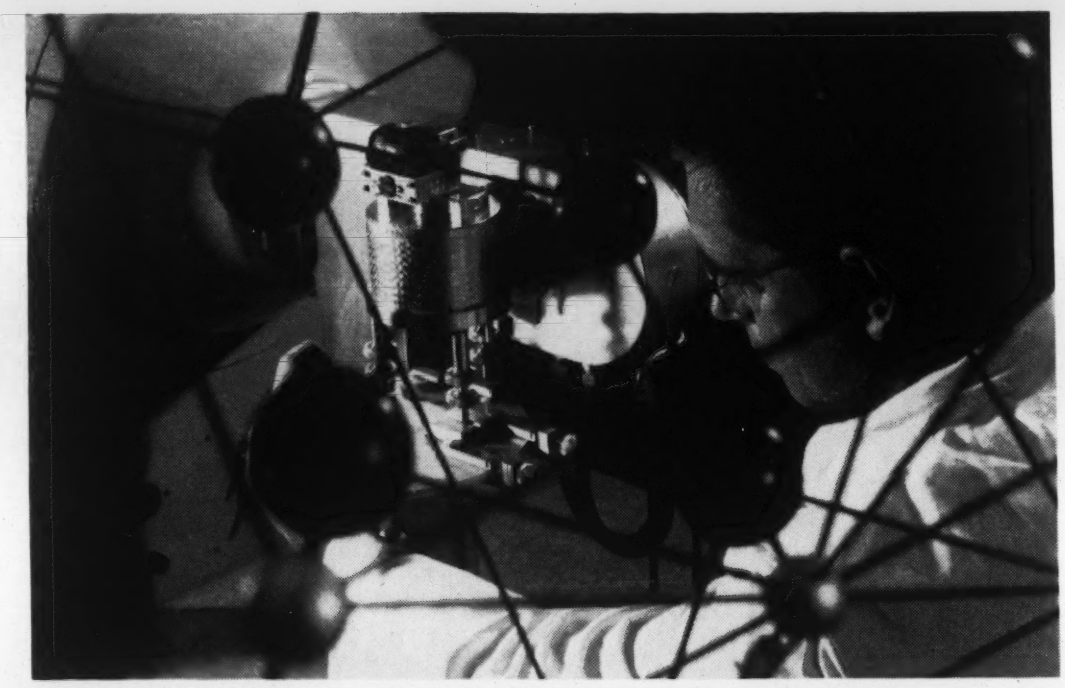
News OF INDUSTRY



***High power** x-ray machine probes atomic structure of matter.*

Powerful X-Ray to Aid Research

■ Development by Westinghouse Electric Corp. of the "world's most powerful" x-ray machine now makes it possible to take x-ray photographs of alloys at the precise moment when the magnetic arrangement of atoms is undergoing transformation due to temperature changes. According to Dr. Abraham Taylor, its designer, the machine will not only make it possible to observe the way in which these alloys react at certain temperatures, but will give metallurgists a greater insight into the reasons for the behavior. (See also article on GE's new x-ray microscope, M&M, Jan '57, p 203.)

Dr. Taylor points out that x-ray time has been reduced sharply because the crystallographic x-ray machine is at least 15 times more powerful than any comparable device now in existence. This unusually high power, and the fact that the x-ray beam can be concentrated on a focal spot less than half the normal size, make it possible to obtain an x-ray source which is 15 times more brilliant than before.

Thus metals research that was previously considered too costly or impractical is now feasible. For example, x-ray photos have been taken at temperatures as low as —300 F. Although this could conceivably be accomplished with less powerful equipment, Dr. Taylor says it would be difficult to maintain accurate temperature control. In addition, because of the long exposure time which would be necessary, the cost of liquid helium, the cooling agent, would be prohibitive. The machine has also been used to study metals as hot as 3000 F.

Design Engineers' Meeting Set for May 20-22

A three day technical conference for designers and engineers, sponsored by the Machine Design Div. of the American Society of Mechanical Engineers, will be held May 20, 21 and 22 in New York City. The conference will run concurrently with the Design Engineering Show at the New York Coliseum.

Of the seven sessions planned, two are of particular interest to those responsible for materials selection. They will be devoted to latest developments in engineering materials. The May 21 session will be concerned with metallic, ceramic and refractory

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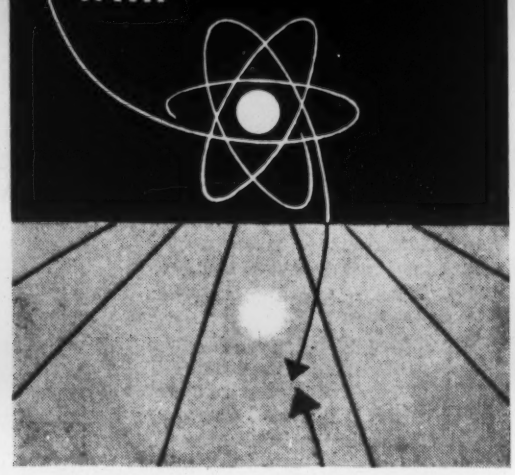

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TECHNIC BIBLIOGRAPHY

Technic publications, authoritative in our field: "Electroplated Gold"; "Precious Metal Electroplating Data: Gold, Rhodium, Palladium, Platinum, Silver, Nickel"; "Electroplated Platinum"; "Electroplated Palladium"; "Electroplated Rhodium"; "Analysis of Gold & Gold Alloy Solutions".

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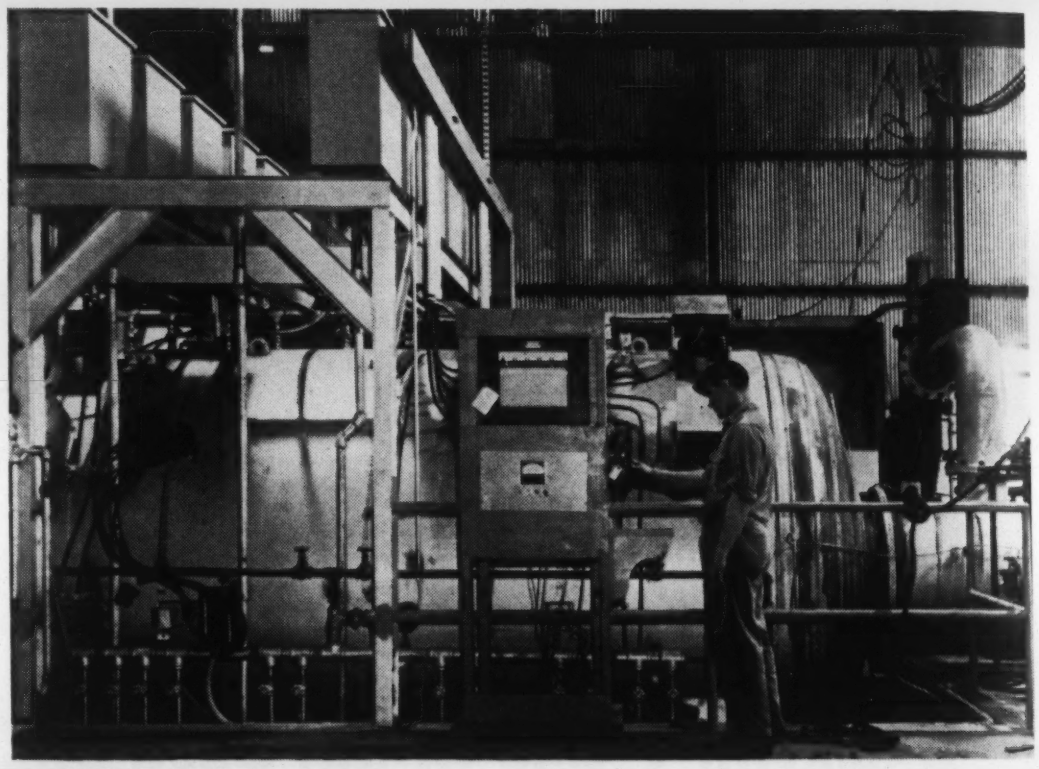
News OF INDUSTRY

materials. The May 22 session will cover plastics, rubber, and finishes and coatings.

The remaining sessions will include discussions of organization and procedures to develop profitable designs, and papers on new developments in mechanical designs, and in electric motors and controls.

The papers committee for the design conference is composed of the editors of the four leading design publications: G. F. Nordenholt, *Product Engineering;* F. Oliver, *Electrical Manufacturing;* C. Carmichael, *Machine Design;* and H. R. Clauser, MATERIALS & METHODS.



Vacuum annealing furnace *can process several tons of sheet per charge.*

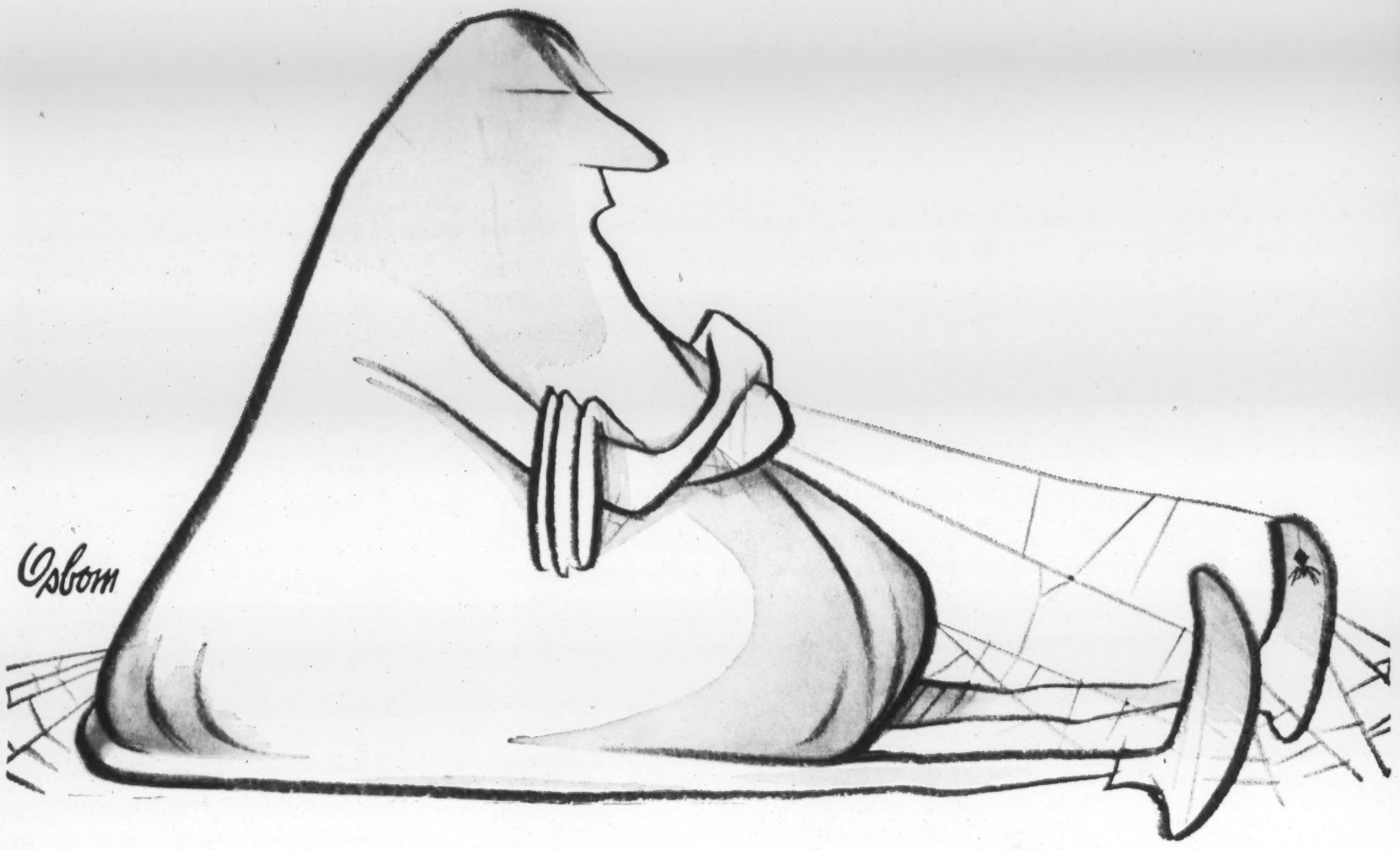
Largest Vacuum Furnace

A vacuum annealing furnace, claimed to be the largest of its type yet built, has gone into service at Mallory-Sharon Titanium Corp., where it will serve the dual purpose of quality improvement and heat treatment of titanium sheets.

The furnace, built by Westinghouse, has a charge space of 4 x 4 x 12 ft and can process several tons of material per charge. The unit has a rating of 450 kw, a maximum operating temperature of 1600 F and can be evacuated to one millionth of an atmosphere. Sheets can be either loaded flat on a charging car, which is then rolled into the furnace, or suspended vertically in the conventional manner.

According to Mallory - Sharon engineers, vacuum annealing will be used where required to reduce hydrogen content of finished titanium sheet. Present specifications generally call for no more than 150 parts per million of hydrogen in titanium sheet. This major installation is part of the company's current expansion program aimed at more than doubling the company's capacity by early 1957. The company's output of titanium mill products is estimated at 1500 tons in 1956, 3500 tons in 1957.

(more News on p 250)



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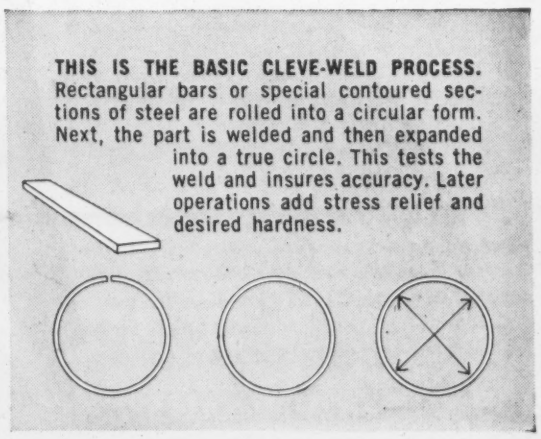

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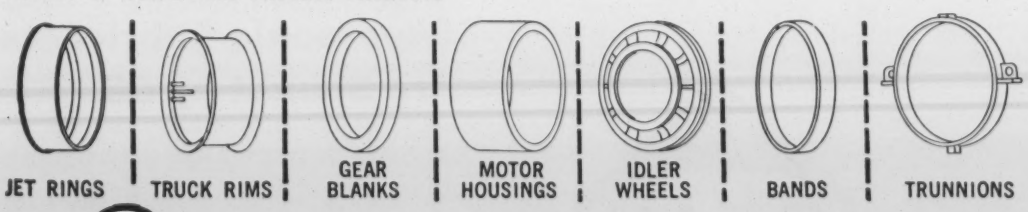

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A lightweight skin section 5 feet by 3 feet in compound contours. One side an airfoil, the other side a heat collection grid of maximum conductivity through the skin. A tolerance of .010" on mating surfaces.

This casting was produced by a unique foundry technique developed by the aluminum foundry of Morris Bean & Co. A rush schedule was met on prototypes, and the casting is now delivered in production quantities.

If you seek new approaches on difficult-to-form access doors, fins, airfoil sections, leading edges, or other problem shapes, you should become acquainted with—

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Resin Producers Asked to Help Molders, Users

A spokesman for the plastics industry has suggested four ways the producers of basic plastics materials can help molders and other processors manufacture good products. According to John O'Connell, chairman of the Society of the Plastics Industry, materials producers should:

1. Suggest to the processor good end uses for their new materials, and educate the processor and the industrial consumer in the selection of the right material by being equally as quick and frank in stressing the weak points of the materials as the strong.

2. Make independent industrial designers and those employed by processors and industrial consumers aware of design features for individual materials which can facilitate processing and make for a more beautiful and useful consumer product.

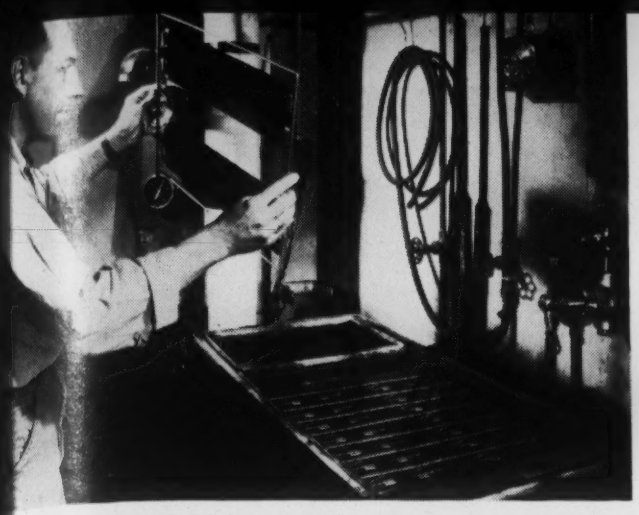
3. Provide a simple, easily remembered, easily identifiable, commercial nomenclature for their materials. These would be good generic terms, not manufacturers' trademarks.

4. Find a more equitable manner of announcing price changes. What the processor seeks here is some form of stability which might possibly be provided by having all price changes occur once or twice each year at certain determined times.

Mr. O'Connell made these suggestions at the recent New England meeting of the SPI.

Supersonic Lubricants Are Sought by GE

Air bearings, which greatly minimize or eliminate friction, and the use of molten metals and molten glass as supersonic lubricants, are among concepts to be studied by General Electric engineers at a $1 million dollar Bear-



150 radiographs every day – that's the production rate of the E. Keeler darkroom. Chief Radiographer Bennett keeps quality high despite rigid schedules.

Welding flaws can be no greater than 2% of metal thickness! Mr. Bennett pinpoints a crack which must be cold-chiseled out by hand, then re-welded.

Starting an x-ray inspection of a longitudinal boiler seam. Chief Radiographer Harold Bennett of the E. Keeler Co., directs tube as Technician Thomas Young adjusts the electromagnetic cassette support.

"Our rugged schedule demands a dependable film . . . Du Pont 504 is a must for us"

—says Chief Radiographer **HAROLD BENNETT** *E. Keeler Company, Williamsport, Pa.*

Three technicians, working with a single 200-kv.p. x-ray machine, turn out an average of 150 boiler weld tests every day at the E. Keeler Plant in Williamsport, Pa. The head of Keeler's x-ray crew, Chief Radiographer Harold Bennett says, "On our rugged schedule dependable speed is really important to us. That's the big reason we're sold on Du Pont 504.

"With the combination of Type 504 and Du Pont 'Patterson' 245 Industrial X-ray Screens, we can keep our exposure factors to a minimum and still get clear, easily interpreted films," continues Mr. Bennett. "What's more, the base clarity of 504 enables us to pinpoint the tiny weld defects (as small as 2% of metal thickness) that put the 'no-go' stamp on a weld."

Keeler's veteran Production Manager, Rudolph Engler, sums up the company's attitude toward x-ray testing. Mr. Engler states flatly: "Without x-ray inspection, quality boilers couldn't be built."

When the quality of your product depends on x-ray inspection, you'll find you can depend on the speed and uniformity of Du Pont X-ray Films. Specify Du Pont X-ray Films on your next order.

FOR MORE INFORMATION, contact the nearest Du Pont District Office or the Du Pont Company, Photo Products Department, Wilmington 98, Del. In Canada: DuPont Company of Canada (1956) Limited, 85 Eglinton Avenue East, Toronto 12, Ontario.

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

DU PONT X-RAY PRODUCTS

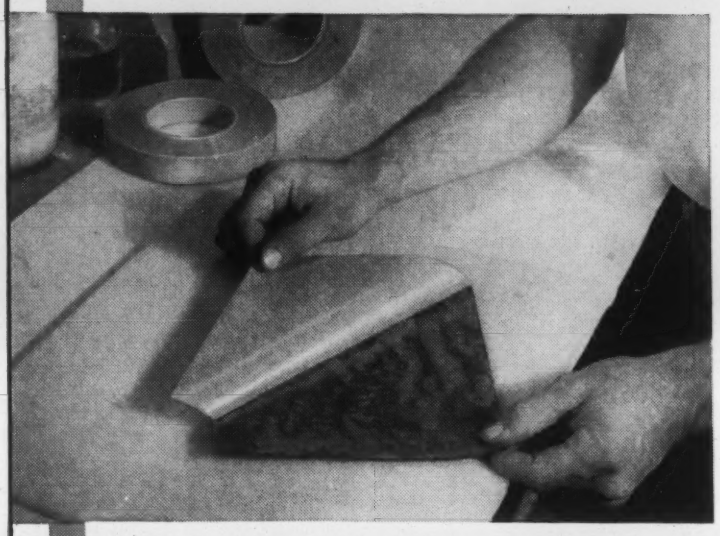
FILMS • "PATTERSON" SCREENS • CHEMICALS

For more information, turn to Reader Service Card, Circle No. 575

the first of its kind

a more versatile medium for

pressure sensitive instant adhesion



ANGIER'S **Double-Face** PRESSURE SENSITIVE **Transfer Film**

Entirely different from conventional double-coated tapes. "Double-Face" is a specially reinforced pressure sensitive mass incorporating the features of conformance, adhesion and aggressive tack provided by many liquid pressure sensitive applications. It is a **translucent** pressure sensitive mass in film form supported by a double-coated release paper which can be either removed at once for instant bonding or at a later date if used on a consumer product.

* TRADE MARK OF INTERCHEMICAL CORPORATION

- adaptable to a full variety of porous and non-porous materials.
- conforms to highly irregular surfaces.
- can be slit or die cut with protective release paper in place.
- eliminates drying and coating equipment.
- speeds production — reduces waste.

Available in rolls: Widths: 1/8" up to 54"
Length: 72 linear yards

3 Types: SOFT MEDIUM FIRM

Write for samples, specifications and prices.

Angier Adhesives

Division of Interchemical Corporation

120 Potter Street Cambridge 42, Mass.

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Latest developments in Adhesives for Honeycomb Construction, Vinyl Film Bonding Rubber, Latex and Resin Cements Pressure Sensitive Cements Flocking Cements Laminants and Sealants Tie Coats Resin Emulsions

ANGIER ADHESIVES

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News OF INDUSTRY

ing and Lubricant Center. The Center will conduct broad research engineering programs, supply consulting service, and carry on advanced development.

Dr. Robert O. Fehr, manager of mechanical engineering for the company's General Engineering Laboratory, said the new center is equipped to carry on advanced development work relating to atomic submarines, jet engines, missiles and satellites and constant improvement in turbines, motors and household appliances. Dr. Fehr predicted that new concepts in bearings and lubricants would bring about the breakthrough needed to meet the demands of the "Space Age."

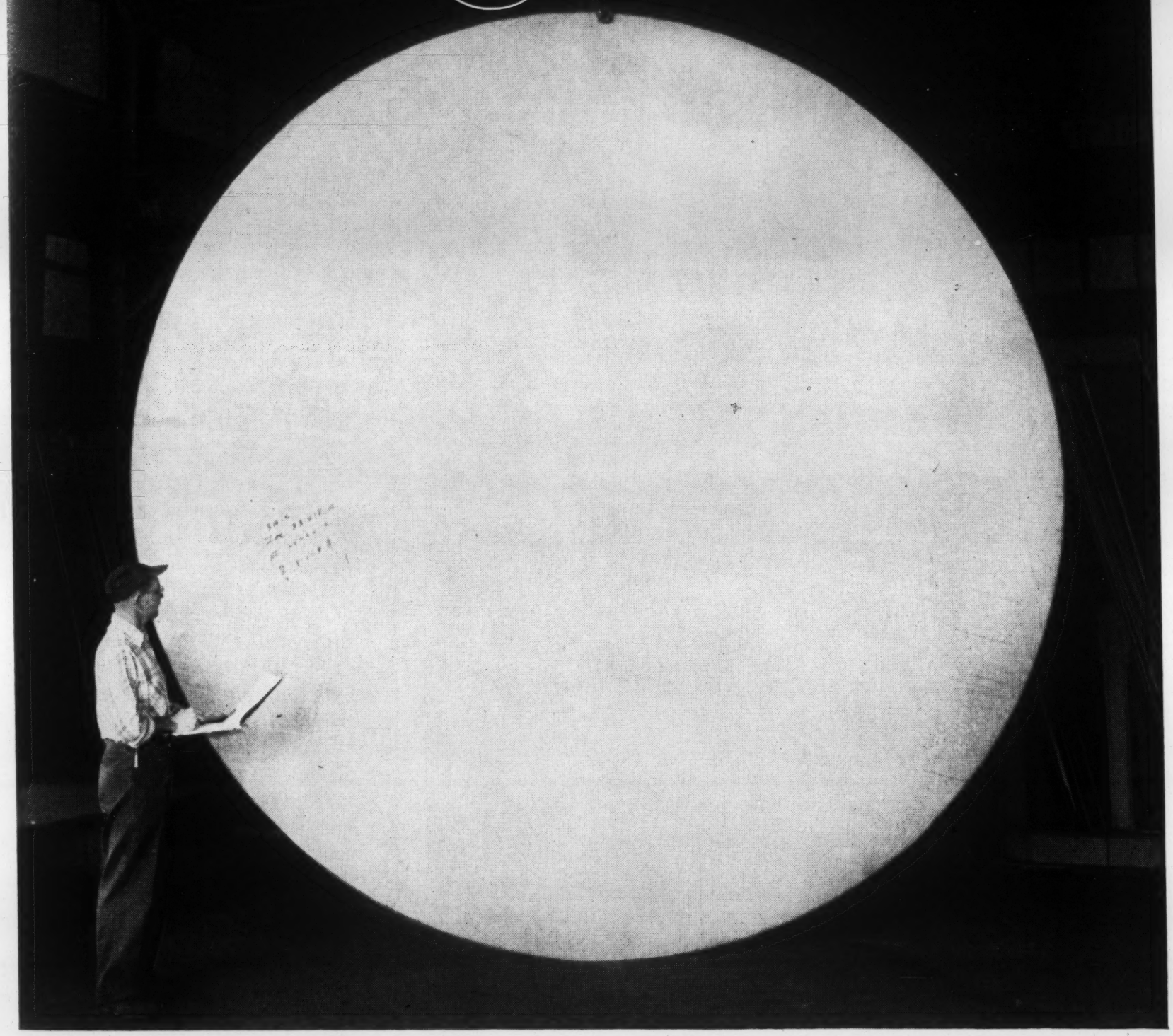
The new Center at Schenectady combines in one location GE's bearings' and lubricants' development facilities, formerly divided between the Thompson Laboratory of the Lynn, Mass., River Works and the General Engineering Laboratory in Schenectady. The combined facility has a staff of 30, including 14 engineers.

First Castings Show To Be Held in May

Designed to demonstrate that castings are "the shortest distance between raw material and finished product," the first Engineered Castings Show, sponsored by American Foundrymen's Society, will take place at the Cincinnati Music Hall May 6 to 10 simultaneously with the 61st AFS Castings Congress. The five-day event will feature a supporting program of technical sessions pointed toward product design engineers and users of cast products.

The twin bill is expected to attract two distinct audiences—the product design-engineering level of industry, which is primarily interested in quality, utility and economy stemming from greater use of cast products; and the pro-

WHY BUY STAINLESS STEEL squares WHEN IT'S circles YOU NEED?



This circle, 9/16" thick x 164" diameter, is one piece of Type 316L stainless steel. Had the customer ordered a square, he would have paid freight on a half-ton of excess material. Also, he would have had the problem and expense of handling the square and cutting the circle.

Here are four sound reasons why Carlson customers save time and money when they order the circles they want—rather than the squares they have to cut . . .

1. If the gauge and size are circle-shearable, there is no extra charge for cutting the circle. This saves cutting labor and scrap handling expense.
2. If the gauge is such that a cutting charge applies to the square, it pays to order the circle. This eliminates the extra charge for cutting the original square and involves only the one charge for cutting the circle.
3. Because circles weigh approximately 25% less than squares, there's a substantial saving in transportation costs.
4. Small or medium size circles are often available from stock when squares may not be. The delivery time saved can be an important factor.

When you need stainless steel circles, come to Carlson where we specialize in stainless steel . . . that's your guarantee of dependable service.

Stainless Steels Exclusively

G. O. CARLSON Inc.

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

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ducers of castings who will attend sessions on foundry methods and techniques.

Exhibits will be in four categories:

1. Companies producing metal castings for sale.
2. Manufacturers of laboratory equipment for testing and quality control.
3. Producers of metals and alloys contributing to castings quality.
4. Companies producing patterns for sale.

Institute for Research Set by Union Carbide

Formation of the Union Carbide Research Institute to engage in basic scientific research has been announced by Morse G. Dial, president of Union Carbide and Carbon Corp.

A major purpose of the institute will be to contribute to the store of fundamental knowledge by studying the physical and chemical behavior of matter under ordinary as well as extreme conditions of pressure and temperature. Work at the institute will complement and extend the basic research now being carried on in the existing research laboratories of Union Carbide and Carbon Corp.

Dr. Augustus Kinzel, vice president, will be chief administrator and Dr. E. R. Jette will direct the institute's activities.

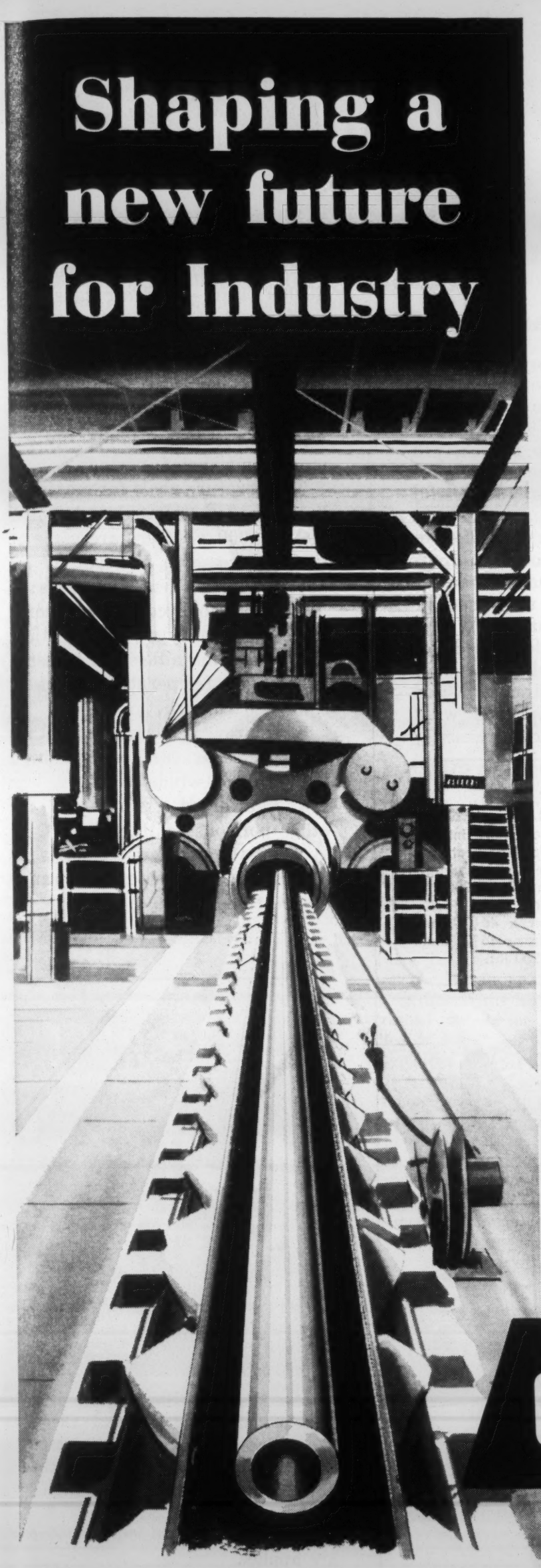
Aircraft Materials Must Stand 3500 F

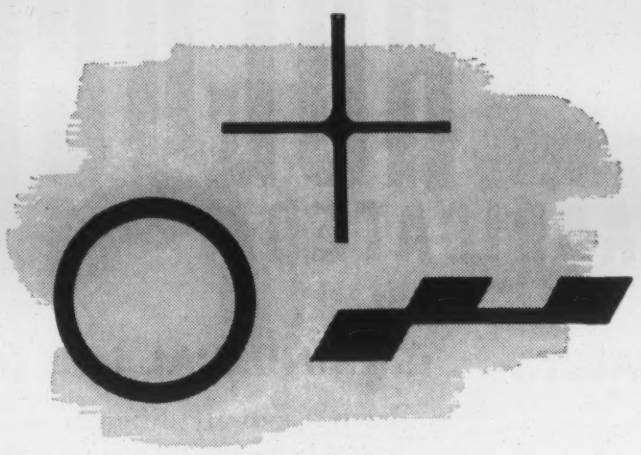
Aircraft materials capable of withstanding temperatures in the range of 1000 to 3500 F will be required in the next ten years, according to a survey made by the Aircraft Research and Testing Committee of the Aircraft Industries Assn.

Victor Mellquist, secretary of

For more information, turn to Reader Service Card, Circle No. 490

Shaping a new future for Industry





CURTISS-WRIGHT extrudes steels in shapes, lengths and sizes never before possible

Curtiss-Wright's Metals Processing Division is pushing steels into new uses for all industries. Shapes and sizes never before possible are being extruded in constantly increasing tonnages from alloy steels, stainless, titanium and other metals.

Starting with billets weighing up to 9000 pounds, the world's largest horizontal steel extrusion press moves the metal into shapes of virtually any profile that can be circumscribed by a 20-inch circle. Or, in a matter of seconds, the raw material may become heavy wall tubing up to 22 inches in diameter.

The 12,000 ton extrusion press and the complete facilities of Curtiss-Wright's Metals Processing Division are ready to go to work for you . . . to advance the design and production of metal products beyond the limitations of conventional equipment. Qualified engineering consultation available at all branch offices.

76 GRIDER STREET

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ROLOCK FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT

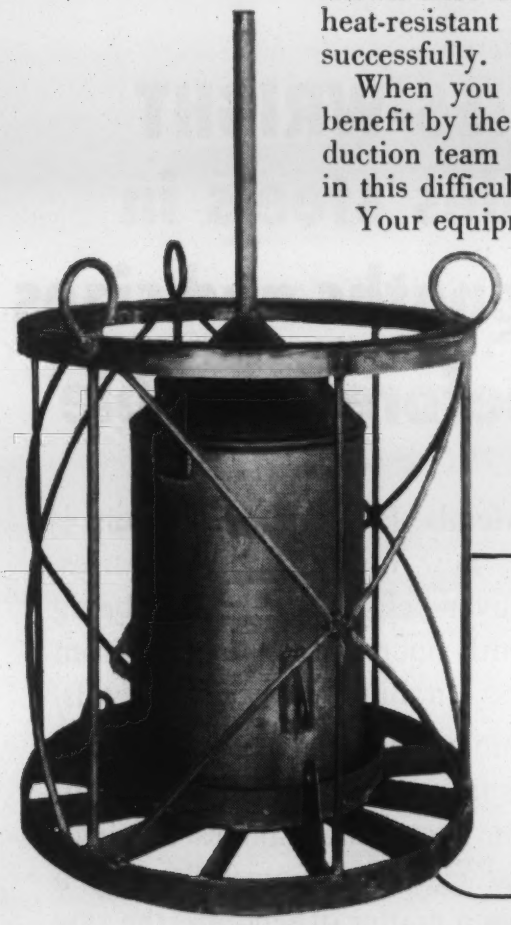
USUALLY . . . the UNUSUAL is a job for ROLOCK

The two entirely different welded alloy fabrications shown here are typical of hundreds of tough high-heat-resistant equipment problems we have solved successfully.

When you bring such problems to Rolock, you benefit by the experience of an engineering and production team that has been exceptionally successful in this difficult field.

Your equipment is built by Rolock specialists in welded fabrication of high-heat-resistant alloys . . . men who know just how to handle these special materials for best results.

Performance is safeguarded by the most careful final inspections, including, where desirable, X-ray examination, or compliance with ASME and other code requirements.



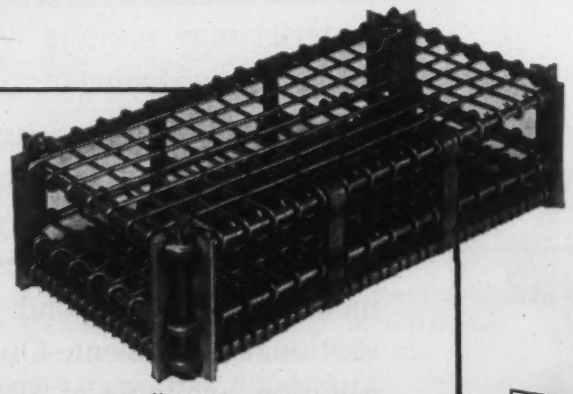
for example . . .

This Inconel retort, sand seal pan, grid support and lifting frame is one of many intricate Rolock welded fabrications for high-heat operation. It is used for brazing in a hydrogen atmosphere, alternately heated to 2200° F., lifted out of the furnace and cooled.

Size: Retort 24" diameter x 46⅝" long, excluding pipe. Supporting frame 46⅜" diameter x 57½" O.A. Weight: 200 lbs.

for example...

This special combination Incoloy heat treating carrier and locating fixture for automotive parts is 10½" x 20" x 4⅞" O.A. . . . typical of Rolock's experienced approach to special-feature design.



Top and middle layers of mesh are 1-3/16" c-c .177 or .187 — pressure-welded and then clinched around ⅜ round rod rings. Bottom layer of mesh is 2 mesh .148. Corner construction is Rolock design (patent applied for).

Write for Rolock's unique Catalog and Data Book, most comprehensive book of its kind available.

SALES AND SERVICE REPRESENTATIVES FROM COAST TO COAST

ROLOCK INC., 1282 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

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News OF INDUSTRY

the ARTC, says the frictional forces produced by an aircraft flying at twice the speed of sound at 40,000 ft in -64 F air cause the surface of the plane to reach a temperature of 250 F. "Mach 3.5 or about 2500 mph is considered to be the critical point beyond which conventional equipment as we know it today cannot fly for more than brief periods."

Temperature goals for materials in 1961 are estimated at between 500 to 1000 F. Here are some of the requirements forecast by industry for the next five years:

1. New honeycomb-type cores for sandwich-type construction.
2. Inorganic adhesives to serve as a high temperature bond in sandwich construction.
3. Improved glass and other optically clear surfaces for high temperature windows.
4. Reinforced laminates for other portions of the aircraft.
5. Fuel containers (plastics or otherwise) for temperature range of 500 to 800 F.

(news of Engineers on p 258)

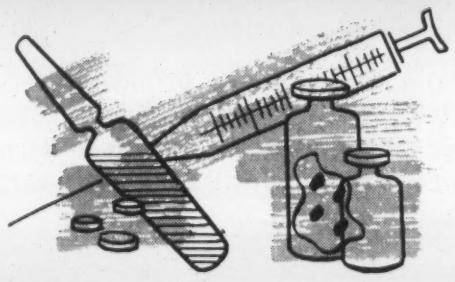
Creep testing—Shown here is the newest portion of General Electric Co.'s creep and rupture testing facilities. Temperatures in these new furnaces, which go as high as 1800 F, are held within ± 2 F. Loads as high as 50,000-100,000 psi are applied.

Which New CO_2 Application Will Help You Most?

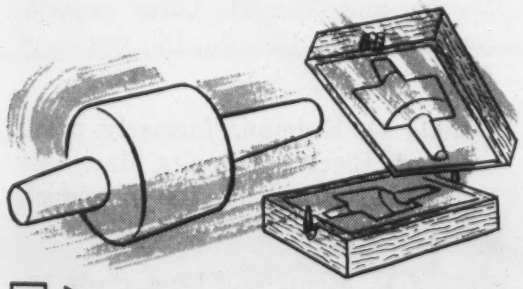
"CO_2 applications are unlimited"... a broad statement, but literally true. New ways in which this most versatile of all gases is improving products, cutting costs and saving time and labor are being developed almost daily. Some of the applications discussed here will be of direct, primary interest to you. Other uses, while perhaps not in your immediate specialty, may well be *adaptable* to your field. Check the box by each application on which you'd like detailed, technical data and mail this page to:

The Liquid Carbonic Corporation • CO_2 Division
3172 South Kedzie Avenue • Chicago 23

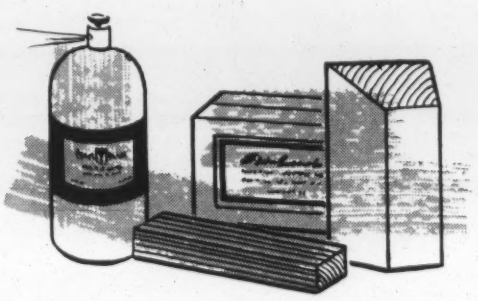
Your inquiry will receive prompt, professional attention from the chemical applications staff of the world's largest producer of CO_2.



☐ ▶ **Economical, Efficient "Freeze-Drying"**—Freeze-drying is used to dehydrate heat sensitive substances at low temperatures. In the processing of blood plasma and the manufacture of penicillin, streptomycin and other pharmaceuticals, dry ice or liquid CO_2 is used to freeze the item being dried. Also, during the drying stage, dry ice is used to condense the moisture as it is sublimed under vacuum. Capable of quickly attaining and maintaining the extreme low temperatures required, CO_2 has the added advantage of requiring only a small capital outlay.

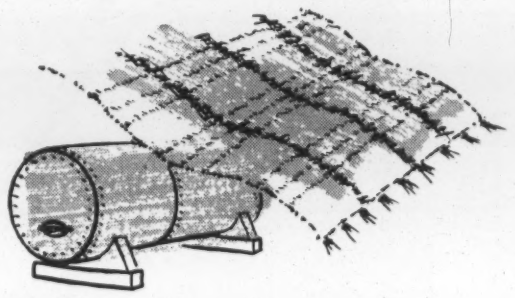


☐ ▶ **Curing Cores and Molds for Foundry Castings**—Ordinary foundry sand cores can be cured in 20 seconds flat, molds cured in an unbelievably short time. CO_2 gas reacting on a special sand binder gives an instantaneous chemical reaction ... eliminates baking, gives sound, hard, perfectly formed cores and molds of any shape or size. CO_2 curing gives more accurate dimensions, too. CO_2 cured molds can be left for several days before pouring.



☐ ▶ **Simplifies Pulverizing of Materials With Low Melting Point**—Many substances tend to melt or smear because of the heat generated in a milling process. DDT and vegetable fat flakes which are waxy and Teflon resin which is very tough and elastic are examples. In the low temperature pulverizing process the ingredient is mixed with crushed dry ice or low pressure carbon dioxide liquid is injected directly into the ingredient. These methods effectively inhibit the melting or smearing, prevents plugging and reduces horse power requirements. Gaseous carbon dioxide is also used to form an atmospheric "blanket" to effectively prevent fire during the grinding of flammable materials. An example of this application is the grinding of phosphorus pentasulphide and flammable resin materials.

☐ ▶ **Economical Gas Shielded Welding**—Costing only 1½ cents per cubic foot, CO_2 gas replaces expensive argon or helium gas in metal-arc gas shielded welding operations. Users report saving an average of 7 cents per cubic foot of gas. Low-cost CO_2 also produces welds that are equal, or superior, to welds made with argon or helium gas. No expensive installations are necessary ... present equipment can often be used "as is" or with modifications.



☐ ▶ **Effective Inerting Agent**—There are many times when an inert atmosphere is needed to prevent fire or explosion. Before welding a tank that has been used for the storage of flammable liquid, CO_2 is used to inert the atmosphere in the tank so that welding can be done with no danger of explosion. CO_2, acting as an effective atmospheric "blanket," also prevents oxidation and "skinning" of paints and oils.

SEND IN THIS PAGE FOR COMPLETE INFORMATION

Check off the applications which interest you, fill in the mailing information below, and mail this page to The Liquid Carbonic Corporation for prompt information. You'll also receive a free copy of our Booklet "Applications Unlimited," which covers dozens of other important uses for CO_2.

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for YOUR product...

the RIGHT sealer!

the RIGHT shape!

Presstite-Keystone manufactures over 400 sealants

—in all sizes and shapes . . . with all kinds of characteristics for all kinds of applications for product improvement. Presstite Sealing Compounds seal in quality by sealing out water, moisture, dust or air—engineered to individual needs.

THIS SERVICE IS YOURS—AT NO COST!

Chances are, the sealant YOU need is among the more than 400 products already available. Describe your needs, include a sketch, if possible, of the area of application and desired characteristics. Our Engineering Dept. will gladly make suggestions.

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For more information, turn to Reader Service Card, Circle No. 568

News OF INDUSTRY

Engineers

Charles F. Kettering, director of General Motors Corp., is the first recipient of the Charles F. Kettering Medal, which is jointly sponsored by six top engineering societies. The award will be made annually to an outstanding engineer "for creative accomplishments for the benefit of mankind, including discovery, invention, improvements in designs or processes within the relationship of materials and energy."

Peter E. Rentschler, president, Hamilton Foundry & Machine Co., has been honored by the Gray Iron Founders' Society with its highest award, the Gold Medal.

Edward McClaud has been appointed chief engineer in charge of product, process and tool engineering, Parker-Hartford Corp.

Dr. Thomas R. Kane, associate professor of mechanical engineering, University of Pennsylvania, has received the 1956 Teaching Award of the University's Engineering Alumni Society.

Kenneth M. Wilhelms has been named superintendent of the Laclede Works, and Glen H. Lufcy superintendent at the Ottawa, Ill., works, of Laclede-Christy Co.

Donald C. Erdman, formerly president of Electro Circuits, Inc., has become assistant to the president, Sperry Products, Inc.

Ronald R. Menti has been made assistant general manager, Latex Fiber Industries, Inc., a subsidiary of United States Rubber Co.

Van H. Leichliter has been appointed president of American Steel & Wire Div., United States Steel Corp., to succeed Walter F. Munford, who has been advanced to assistant executive vice president — operations of the corporation.

B. G. Bowden is director of styling and industrial design for John Wood Co.

Herman Tachau, engineer with the New Mexico State Highway Dept., has received the first award of $5000 in the recent competition for ideas to accelerate the progress of arc weld-

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from LAMTEX...

Not one, but two new epoxy laminates..

...with properties made to order for your mechanical and electrical design problems.

LAMINATED FIBERGLASS-EPOXY TUBING, a new Lamtex material with 12 BIG PLUS FEATURES:

- LONG LENGTHS, 9 FT. OR MORE
- THIN WALLS, to .008"
- ALL SHAPES & SIZES
- PRECISE CONCENTRICITY
- HI-TEMP. TO 400°F
- ELECTRICAL INSULATION
- MOISTURE PROOF
- CORROSION RESISTANT
- LIGHT WEIGHT
- HIGH STRENGTH
- DIMENSIONAL STABILITY
- CONTINUOUS WEAVE

ALSO—Tuff-Tube plated or bonded with copper, nickel, silver, or gold for precision printed circuits.

POROUS WALL FIBERGLASS-EPOXY TUBING. An exclusive Lamtex process now makes possible the only hi-quality laminated tubing with *controlled* wall porosity, ideal for:

- Reinforced forms
- Hi-temp. potting
- Motor & synchro housings
- Nozzles
- Capacitor spacers
- Filters
- Screens
- Electroplating fixtures

Research, development, and manufacture of high quality industrial laminates. Special attention to prototype orders and new applications...design recommendations submitted without obligation.

GET FULL DETAILS... Write or call for brochures with design features, tech data, application notes.

LAMTEX

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This *NEW SOURCE* for Extruded Polyethylene Sheet gives a double bonus—lustrous* **SUPER-SHEEN** Finish *PLUS* more uniform sheet thickness. Large stocks ready for immediate shipment. 0.010 in. to 0.125 in. thicknesses in 40 in., 44 in. & 48 in. widths.

Westlake plastics co.

155 W. Lenni Rd., Lenni Mills, Pa.
In lower Delaware Valley, U.S.A.
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Visit the Dynamic World of Plastics

An industry-wide trade show featuring new materials... new methods ... new equipment... and new applications from the plastics industry. Plan now to attend.

Please request tickets on your company letterhead, since there are no general public admissions.

Pacific Coast Plastics Exposition

March 18-21, 1957

Shrine Exposition Hall, Los Angeles, California

Sponsored by: The Society of the Plastics Industry, Inc.

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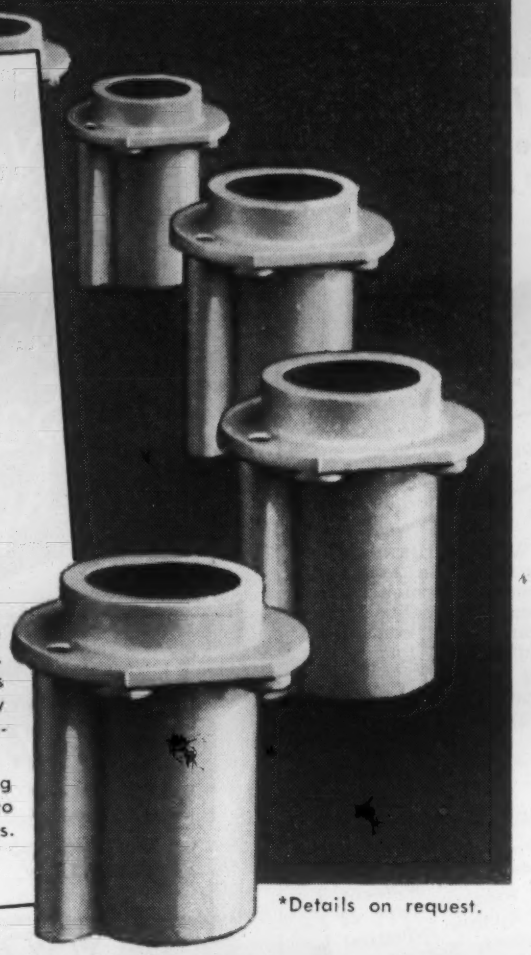
HOW INDUSTRY USES
INVESTMENT CASTING TO GET

5 parts for the price of 1

By reducing 22 separate set-ups and more than 30 different machine operations to 5 machine operations after INVESTMENT CASTING, the cost of producing these control cylinder housings was cut to the point that now five cylinder assemblies are produced at the original cost of one*.

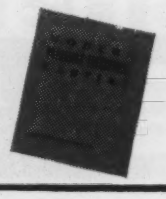
The advantages of Investment Casting are many. It can save money in production costs. It can make possible the use of harder alloys for longer machine life. And it can simplify many design problems now considered impractical.

Get the full story of Investment Casting today. You may find in it the solution to some of your production or design problems.



*Details on request.

Send for our latest 12-page booklet, "Modern Precision Investment Casting." It gives you full details of the "how and why" of Investment Casting.



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Precision Casting Equipment and Supplies
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Photo and data courtesy of Precision Metalsmiths, Inc.

McDANEL Mullite Combustion Tubes

GAS-TIGHT! STRAIGHT!
Low coefficient of expansion with maximum thermal shock resistance. High accuracy bore, exact wall thickness. Open end precisely ground for perfect stopper fit.

RESIST THERMAL SHOCK!
McDanel Mullite Combustion Tubes are recommended for service temperatures up to 2,900 degrees F. Straight or tapered ends, or self-cooling (double-reduced) design.

McDANEL Industrial CERAMICS

McDANEL
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Write Today for Bulletin C1-55 on McDanel Combustion Tubes and Accessories.

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News OF INDUSTRY

ing sponsored by James F. Lincoln Arc Welding Foundation.

J. L. Mauthe has been elected chairman of the board, Youngstown Sheet and Tube Co.

E. C. Sargent has advanced to president of Zirconium Corp. of America.

William J. Snodden has been appointed director of research, Yale Rubber Mfg. Co.

Harry A. Fedderson is now technical director, Loven Chemical of California.

Admiral William M. Fechteler (USN, ret.), former Chief of Naval Operations, has been named planning consultant, Atomic Products Div., General Electric Co.

Thornton F. Holder has been appointed director of research, Diamond Alkali Co.

Kenneth W. Donle has been appointed manager of product engineering, Tube Reducing Corp. He was previously chief metallurgist.

Dr. Lawrence M. Kushner has been selected to head the newly organized Metal Physics Section of the National Bureau of Standards' Metallurgy Div.

Henry M. Haase has been elected vice president in charge of engineering and research, Borg-Warner Corp.

J. S. Gillespie has been named manager of engineering, Metallurgical Products Dept., General Electric Co.

Leonard J. Edwards was recently appointed manager of W. S. Rockwell Co.'s Furnace and Oven Div.

Donald H. Getz has joined W. R. Grace & Co.'s Technical Dept. as a senior process engineer.

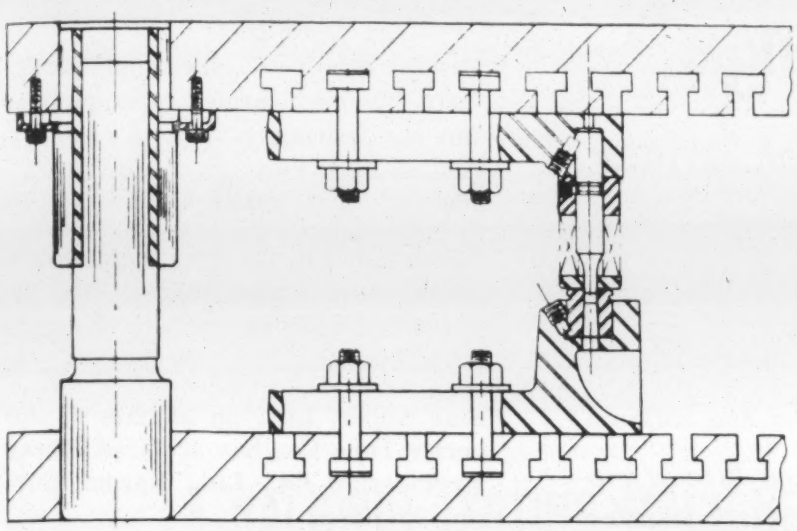
Dr. C. H. Moore has been appointed executive director of corporate research and development, P. R. Mallory & Co., Inc.

Harry L. Jenter has been named vice president-operations, American Steel & Wire Div., U.S. Steel Corp.; other AS&W appointments include Walter L. Longnecker, Cleveland district manager of operations; and James J. Dalton, general superintendent.

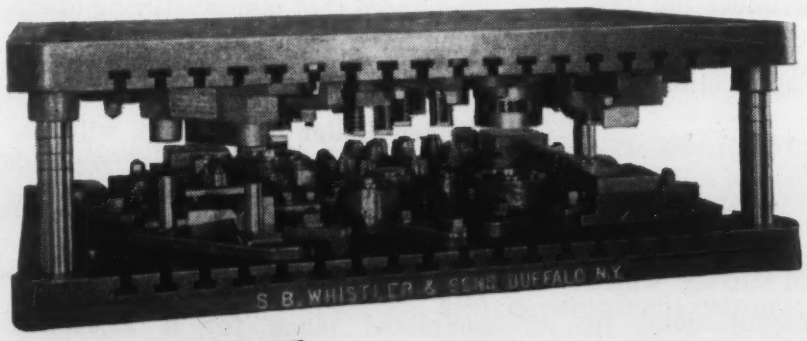
(news of Companies on p 262)

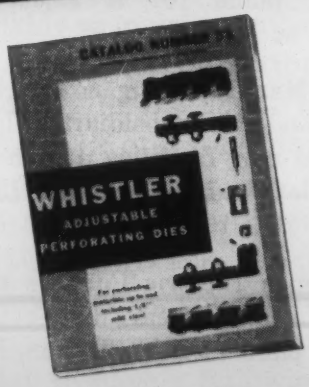
ADJUSTABLE DIES by WHISTLER

• Operate like a single purpose die • Easy to set-up and make changes • Interchangeable and re-usable parts always ready for a new job • Reduce die costs to a new low • Pierce holes in any desired arrangement of shapes and sizes • Precision piercing of materials to ¼" thick steel.



Above: Sectional drawing of a Whistler adjustable punch and die unit assembled in T-slot die set. **Below:** A completely assembled Whistler adjustable die ready for the press.





YOU NEED THIS CATALOG

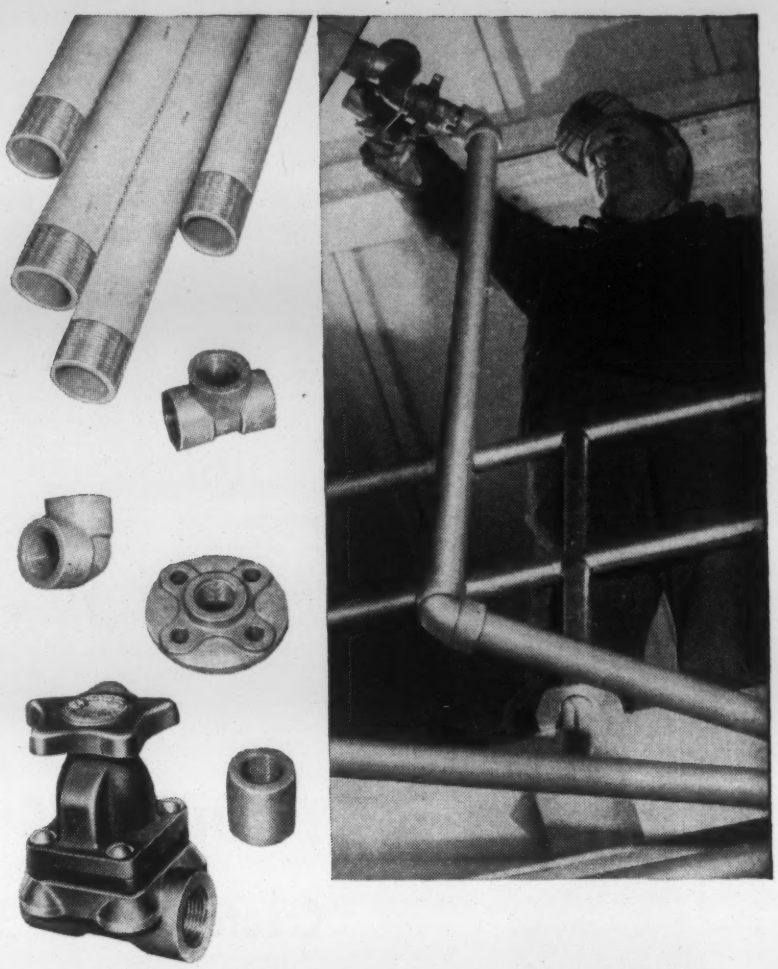
to see for yourself in dollars and cents what this adjustable die making method can do for your plant. Send for it right now...without obligation.

S. B. WHISTLER & SONS, INC.
741 Military Road, Buffalo 23, N. Y.

ADJUSTABLE, MAGNETIC and CUSTOM DIES FOR ALL INDUSTRY
Direct Factory Representatives Located in Principal Industrial Areas

1957—Our 40th Year Manufacturing Dies

For more information, turn to Reader Service Card, Circle No. 379



Peak Performance by *Van-Cor*

PIPING

An Ohio plant was faced with high pipe maintenance costs because the acetic acid produced is strong enough to eat holes in steel. Instead they installed Van-Cor plastic piping that is still good as new after 18 months' service.

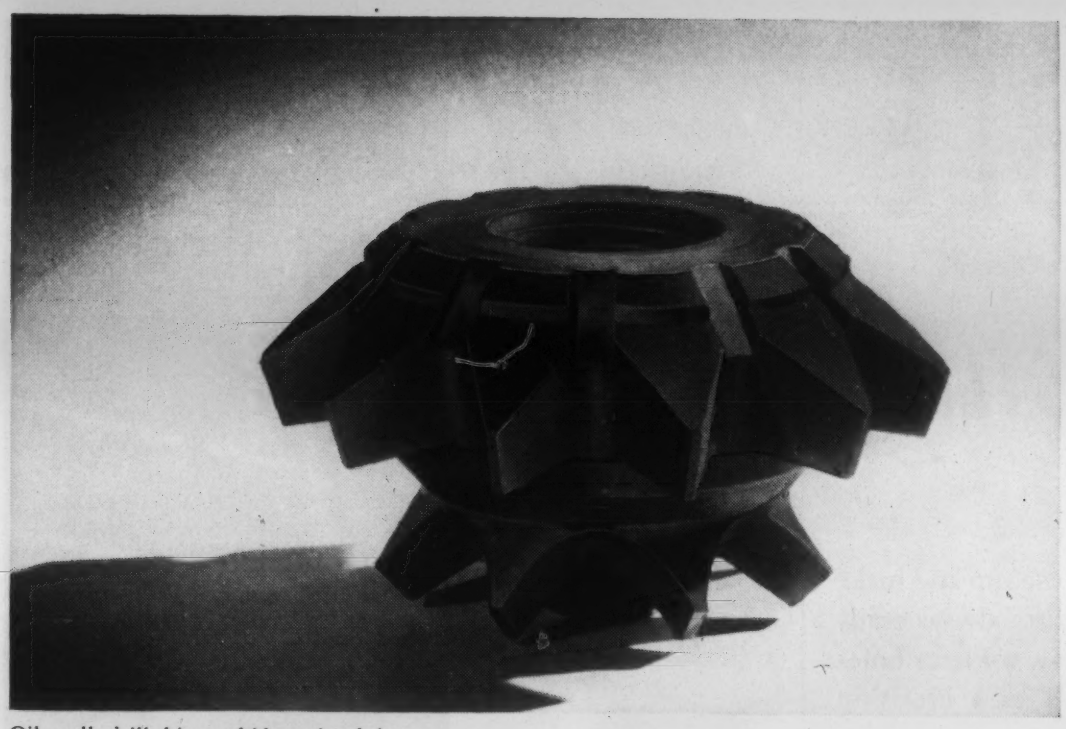
Van-Cor pipe, fittings and valves have solved similar problems with scores of corrosive chemicals. An unplasticized polyvinyl chloride, Van-Cor weighs less, and is easier to install, than conventional piping. It serves longer, thus costs far less . . . Van-Cor sheets are also fabricated into ducts, hoods, tanks, fumestacks, etc.

INVESTIGATE!
Write for Bulletin, Specifications and Name of Nearest Distributor.

INDUSTRIAL DIVISION OF
COLONIAL PLASTICS MFG. CO.

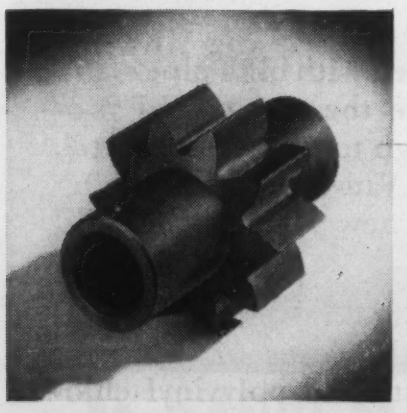
SUBSIDIARY OF THE VAN DORN IRON WORKS CO.
2685 EAST 79th STREET • CLEVELAND 4, OHIO

For more information, turn to Reader Service Card, Circle No. 479

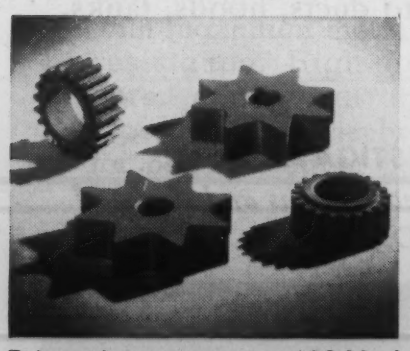


Oil well drill bit, carbide-surfaced by ASC, outlasts 5 untreated bits . . . cuts downtime 50% for oil exploration company.

The original stainless steel crimping roller showed definite signs of wear after processing 1 to 1½ million food cans. Identical rollers, ASC treated, processed 28 million food cans . . . showing no appreciable wear.



An ASC treated gear pump component outlasts 6 untreated units. In addition, its corrosion and heat resistance prevents contamination of the plastic material being processed.



Drive and spur gears, after ASC Metal Diffusion Treatment, have 3 to 4 times the wear resistance of untreated gears.

Atom Exchange

Creates Carbide Wear Surface On Steel Parts

Iron, steel and ferrous-base products which have to take the punishment of severe wear can now be given a treatment which vastly increases their resistance to wear and abrasion.

The new ASC Metal Diffusion Process produces a chromium-carbide surface on steel parts — medium and high carbon, regular, alloy or stainless.

The surface hardness, RC70-72, provides at least three times normal wear under the most difficult operating conditions . . . 10 to 30 times normal wear for many applications.

Even *stainless steel* can be vastly improved wearwise.

By *atom exchange* ASC Metal Diffusion Process produces a chromium surface which is an integral part of the parent metal. In addition to providing wear and abrasion resistance, this surface affords corrosion and heat resistance equal to 430 Stainless Steel.

Further information about this revolutionary process is yours for the asking. Write for additional data, consultation, or product demonstration.

ALLOY SURFACES COMPANY

103 South Justison Street, Wilmington 1, Delaware

For more information, turn to Reader Service Card, Circle No. 521

News OF INDUSTRY

Companies

Minneapolis-Honeywell Regulator Co. will construct a half-million dollar manufacturing facility in Wabash, Ind. The building will be used for the production of electronic air cleaning equipment and other specialized metal products for residential and commercial temperature control systems.

Pennsalt Chemicals has acquired **Delco Chemicals, Inc.,** through an exchange of stock.

A. O. Smith Engineering Service Corp. has been formed to supplement the engineering programs now carried on by the twelve operating divisions of **A. O. Smith Corp.**

Speer Carbon Co. has begun construction of a new research and development laboratory in Niagara Falls, N. Y.

Fine Tubes, Ltd., an affiliate of **Superior Tube Co.,** has acquired **Moray Engineering Co., Ltd.,** Epsom, Surrey, England.

Sutter Products Co. has moved to Holly, Mich.

Sylvania Electric Products Inc. has announced that manufacturing operations have begun at its Parts Div.'s new plastics plant in Warren, Pa.

Timken Roller Bearing Co. will construct a new metallurgical research laboratory adjacent to its Steel and Tube Div. offices in Canton, Ohio.

Titan Metal Manufacturing Co. has completed plans for a $2,500,000 brass mill at Newark, Calif.

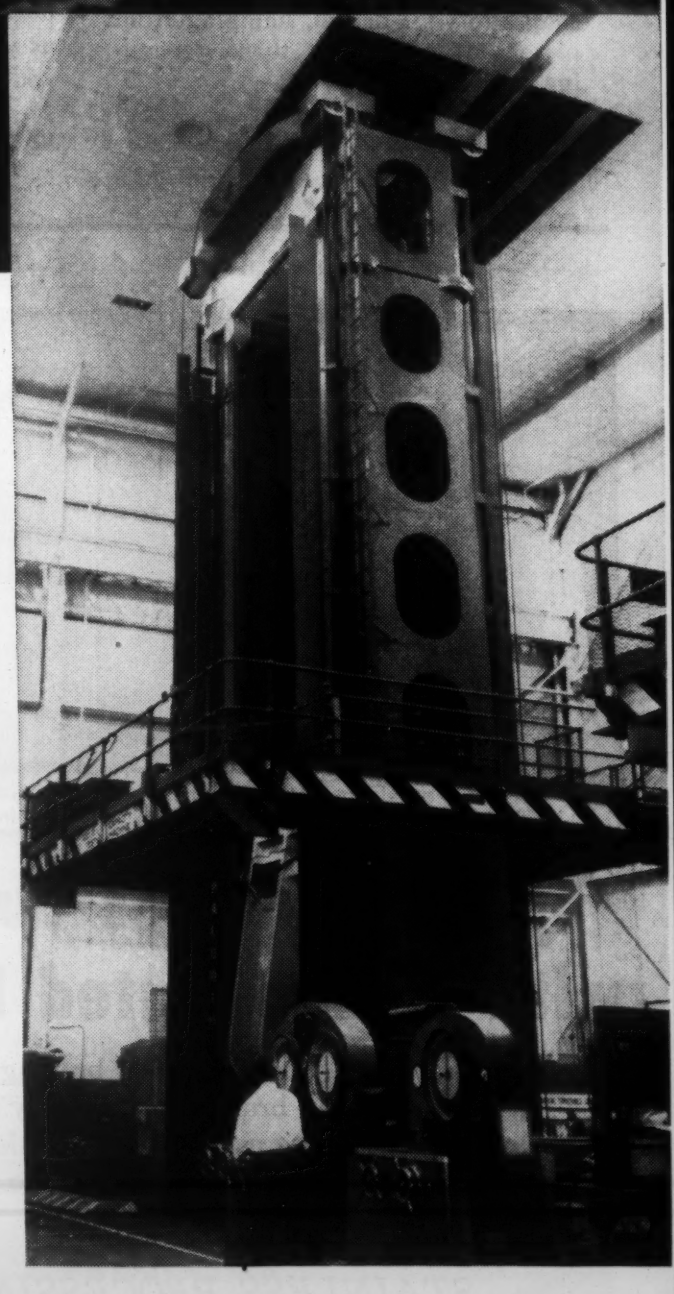
Tri-Point Manufacturing & Developing Co. and its subsidiaries have moved into new facilities at 175-177 I. U. Willets Rd., Albertson, Long Island, N. Y.

Westinghouse Electric Corp. is constructing a switchgear distribution apparatus plant at Bloomington, Ind.

L. A. Young Spring & Wire Corp. has purchased the assets of **Extruded Hinge Co.**

Metal & Thermit Corp. has purchased a 163-acre site near Carrollton, Ky., and will soon begin con-

Official Navy photograph



A BALDWIN TESTING MACHINE WAS USED TO FRACTURE THE ANCHOR CABLE OF A CARRIER

For the best in testing, see Baldwin first

Philadelphia Navy Yard's 5-million-lb. Baldwin BTE Universal Testing Machine was used to actually fracture a link similar to those in the anchor cable of the U.S.S. *Forrestal*, newest giant carrier. The Navy has long recognized the importance of testing in its continuing research and development program. In this, Baldwin plays an important role.

For precision performance in production and quality control testing in the shop, or for research testing in the laboratory, Baldwin offers a complete line of testing equipment. The BTE universal testing line, for example, includes many models, standard, semistandard, and specially engineered. Capacities run as low as 10,000 lb. maximum capacity, as high as 5 million lb.

Whatever your testing problem, compression, tension, creep, fatigue, impact or torsion, bring it to Baldwin. Or write today and ask to have a Baldwin representative call on you.

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

Waltham, Mass.

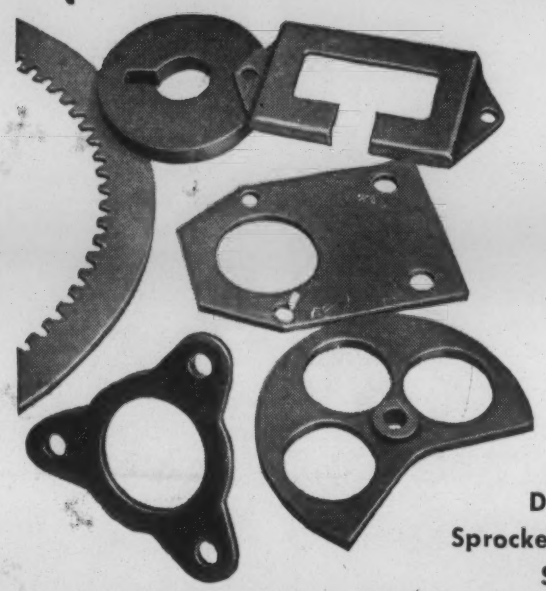
Testing machines • SR-4® strain gages • Transducers

BALDWIN BLH LIMA-HAMILTON

For more information, turn to Reader Service Card, Circle No. 452

For more information, turn to Reader Service Card, Circle No. 434

for Flat Parts in rugged service consider steel plate



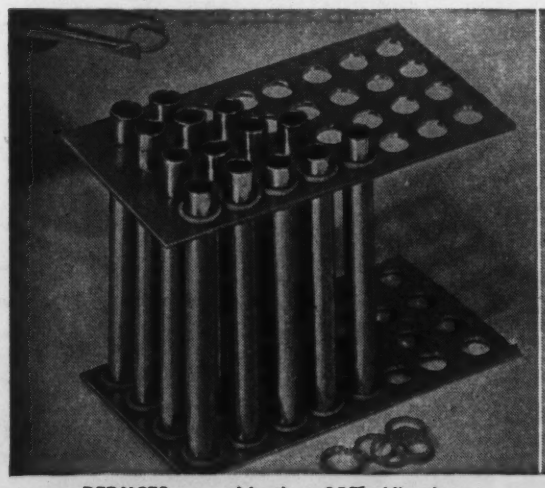
Parts that must be strictly *flat* — of guaranteed accurate thickness and *tough* — often can be stamped from steel plate, economically, with excellent results. Here are a few examples — similar, perhaps, to some you use or are planning.

Heavy duty Washers Rings
Discs or Circles Gear Blanks
Sprocket Blanks Special Bosses Drive Plates
Special Shapes, your own design

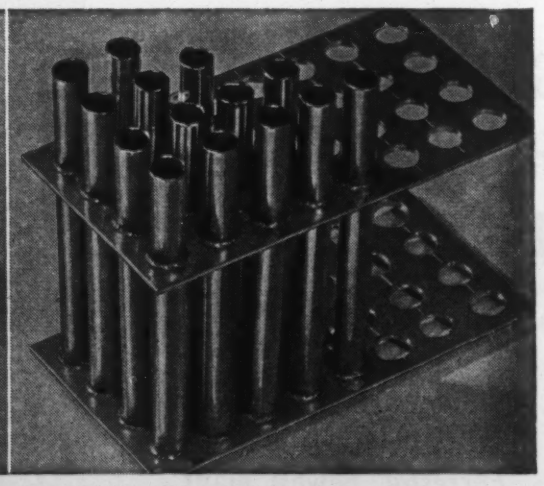
If your steel part starts with a flat disc, for instance — we have stock dies for almost every fractional diameter up to 26½ inches. The heaviest blanking press in the Mid-west accommodates these dies, or those for special shapes to your design, stamping from plate 3/16″ to 1-1/4″ thick, depending on area.

Extra operations available: flame cutting of thicker plate, holes punched (up to .003″ accuracy), machining, grinding, drilling and heat treating. Thirty-five hundred ton inventory of mild and high carbon plate . . . Send us your specifications — let us quote you on price and delivery.

Cleveland Pressed Products Corporation
6714 Union Ave., Cleveland 5, Ohio • VUlcan 3-7900



REDUCES assembly time 85%. Nicrobraz rings are simply slipped over tube ends.



ELIMINATES material waste and rejects. Rings produce perfect joints every time.

Speed Stainless Tube Assembly with Prefabricated Brazing Rings

Nicrobraz, the stainless steel brazing alloy, is now available as prefabricated brazing rings. They'll speed the fabrication and increase the quality of all stainless steel tubular assemblies. Ring sizes and alloy grades to suit your needs. Write for complete information today.

STAINLESS PROCESSING DIVISION
WALL COLMONOY CORPORATION
19345 John R Street • Detroit 3, Michigan

PENNSYLVANIA: Bristol Pike, Morrisville, Pa., CALIFORNIA: 1565 Bluff Road, Montebello, Cal.

For more information, turn to Reader Service Card, Circle No. 415

News OF INDUSTRY

struction of a new chemical processing plant.

F. G. Ludwig, Inc., has purchased **Gull Reinforced Plastics, Inc.**

American Can Co. has announced plans of a $27 million expansion program for the processing of tinplate and steelplate.

Aerotest Laboratories, Inc. has moved to new quarters at 129-11 18th Ave., College Pt., N. Y.

Imprex Division is the new name of the division of Ideal Industries formerly known as **Tincher Products Co.**

National Aniline Div., Allied Chemical & Dye Corp., has completed construction of a multi-million dollar plant which will produce organic isocyanates.

Garret Corp. has acquired a six-acre site for future expansion. Corning Glass Works will build a new Apparatus Plant.

Proctor Electric Co. has increased manufacturing and warehousing facilities in its Maryland plant by 50,000 sq ft.

Dearborn Gage Co. has purchased a 10-acre tract for expansion purposes in Garden City, Detroit.

GAR Electrical Instrument Corp. has moved its entire facilities and operations to Wayland, Mass.

Kuma Tool Co., Div. of Production Tool Corp., has moved to larger quarters at 3845 S. Lowe Ave., Chicago, Ill.

Packless Metal Hose, Inc. has moved from New Rochelle to larger quarters in Mt. Vernon, N. Y.

Hagan Chemicals & Controls, Inc. is the new name of the company formerly known as Hagan Corp.

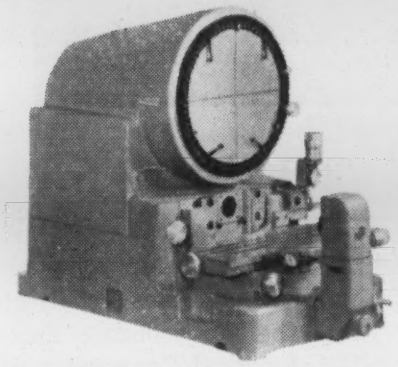
Carborundum Co. will build a new multi-million dollar plant in Van Wert, Ohio, for the manufacture of high volume, small abrasive wheels.

Automatic Molding Machine Co. has transferred its operations to a new plant in Los Angeles, Calif.

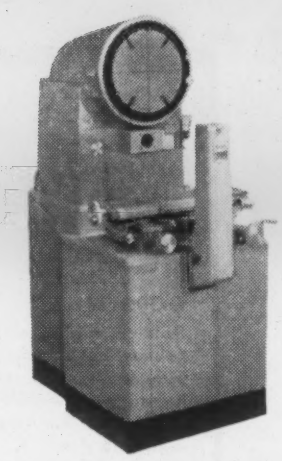
Allis-Chalmers Ltd., Canada, has announced construction of a 17,000-sq-ft addition to its St. Thomas Works.

(news of Societies on p 266)

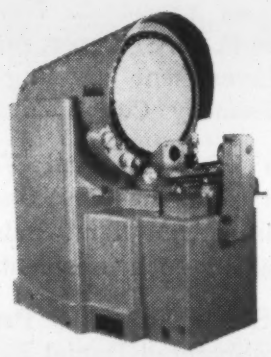
Speed production with projection gaging . . . and the *right* KODAK CONTOUR PROJECTOR



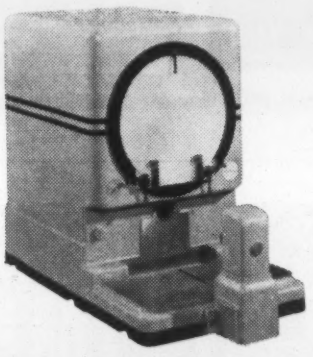
Model 14-2A—Do you need a versatile precision measuring instrument for toolroom or production lines? Kodak Model 14-2A measures intricate parts to the order of .0001″, lets you do routine gaging by comparing the part with a chart. Measuring attachment is equipped with micrometer guaranteed accurate to .00005″ over the entire 1″ range. Dial indicator ends need for micrometer feel. Kodak Measuring Blocks, in standard dimensions, can be inserted in the horizontal and vertical micrometers to cover full travel range. Has 14-inch screen. *You can use any Kodak Contour Projector anywhere in normal light.*



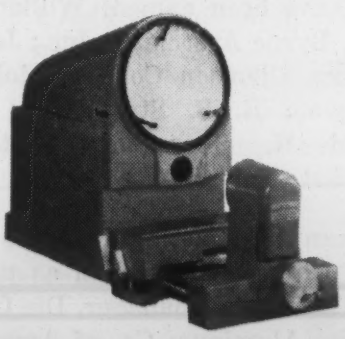
Model 14-5—Are the parts you have to inspect heavy? Model 14-5, optically the same as Model 14-2A, comes with an extra-large, heavy-duty worktable; its box-like construction withstands great weight without measurable deviation. Model 14-5 has the same measuring range as the Model 30, with 8 inches of table travel in both horizontal and vertical planes. *Optical inspection requires little training, and Kodak Contour Projectors are designed with the operator's convenience in mind.*



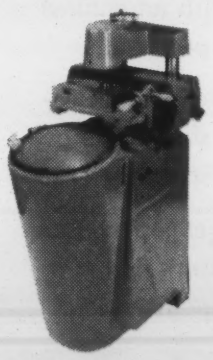
Model 30—A heavy-duty worktable plus a 30-inch screen makes this the model for toolroom or production inspection of large parts. Table traverse is 8″ in both horizontal and vertical planes, focusing travel totals 3″. Engraved dial, calibrated to 2′ of arc, permits angular measurement reading directly, without need of vernier. *The versatility of optical inspection and the adaptability of Kodak Contour Projectors let you do many measurement tasks with one unit.*



Model 3—Check long runs quickly and accurately with this low-cost instrument. Designed for use with your own staging fixtures, Model 3 comes with flat stationary table. Adjustable chart holder permits "set lines" on ground-glass overlay chart to be brought to coincidence with "set surfaces" of the fixture, avoiding need for table movement. *Seemingly impossible-to-measure shoulders, holes, angles, and relationships are easily gaged on Kodak Contour Projectors.*



Model 8—Inspect horizontally and vertically, anywhere in your plant with Model 8. Take this cast-aluminum unit wherever there's need for fast, accurate inspection of small parts. For horizontal inspection, simply stage the part in a simple holding fixture. For vertical measuring, turn Model 8 on end and stage the part on a flat glass stage. Part image on the 8-inch screen is erect and unreversed both ways. Six magnifications from 10× to 100×. *Kodak Contour Projectors have rugged housings to more than withstand conditions of normal use.*



Eliminate receiving inspection bottlenecks, avoid waste on reject parts, predict tool failure before it occurs, speed inspection to match production, make final measurements. Which of these Kodak Contour Projectors will solve your production problem?

How to learn more about Kodak Contour Projectors

From the Kodak Ektar Lens system, (heart of Kodak Contour Projectors), to the precision machining of critical parts, these units are built to meet your most rigid requirements.

To the basic Projector, you can add a number of optional staging and measuring attachments. Your Kodak Representative will be glad to describe these to you and explain their uses.

For the name of our representative or for a descriptive catalog on Kodak Contour Projectors, write to Special Products Sales Division, Eastman Kodak Company, Rochester 4, N. Y.

EASTMAN KODAK COMPANY
Rochester 4, N. Y.

the
KODAK
CONTOUR
PROJECTOR

Kodak
TRADEMARK

For more information, turn to Reader Service Card, Circle No. 366

For more information, turn to Reader Service Card, Circle No. 446

GOSHEN
GORSIL*

*Trade name for Silicone Rubber compounds custom-formulated by Goshen Rubber Co., Inc.

when it comes to SILICONE RUBBER PARTS (molded, lathe-cut or metal bonded) from CUSTOM FORMULATED COMPOUNDS come to Goshen Rubber

MOLDED

LATHE-CUT

BONDED-TO-METAL

A wide selection of specification-standard and custom-formulated silicone rubber compounds are at your command for precision fabrication by Goshen of products requiring properties like these:

- Resistance to temperature extremes, —80° to +500°F.
- Resiliency over a range of —120°F to +600°F.
- Low compression set.
- Resistance to chemicals, oils, oxidation, ozone, weathering, moisture, fungus, corrosion, shock, abrasion.
- Freedom from stain, odor, tackiness and toxicity.
- Same shrinkage as organic rubbers, with resultant advantages.

SEND FOR LITERATURE --- 8-page brochure and technical bulletins tell how you can put Goshen Rubber to work for you. Send for your free copies today!

EXCLUSIVE Goshen Rubber DEVELOPMENTS

GORSYN
Synthetic rubber compounds (not silicones) withstanding temperature ranges of —65°F to +300°F, and —20°F to +400°F.

GORLUBE
Low-friction treatment, for O-rings and parts made of natural, synthetic and silicone rubbers.

GORBOND
Process for securely bonding rubber parts to metals of most every kind.

TETRASEAL
A precision-cut, rectangular-section static seal. Interchangeable with standard O-rings.

See our catalog in Sweet's Product Design File.

QUALITY ENGINEERED RUBBER PRODUCTS

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GOSHEN RUBBER CO., INC., 3127 S. TENTH ST., GOSHEN, IND.

PRECISION-CUT PARTS

our business since 1899

There is no phase in the production of wool felt in which Western Felt is not engaged. We start with lambs wool, and end with an endless variety of parts for the many jobs that only felt can perform.

Through it all, we're proud to say our methods have built an enviable reputation for engineering precision. Hard or soft, large or small, Western Felts can be relied upon to meet your specifications.

Tell us your basic problem—and we'll put 55 years experience to work in recommending a solution for you. Our engineers find new uses for felt every day. Your inquiry will receive prompt attention.

WESTERN Felt WORKS
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Chicago 23, Illinois
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELTS

For more information, turn to Reader Service Card, Circle No. 550

News OF INDUSTRY

Societies

American Society for Metals has appointed Dr. Zay Jeffries as director general of the forthcoming Second World Metallurgical Congress.

Gray Iron Founders' Society, at its recent annual meeting, elected the following officers: president—J. Scott Parrish, Jr., president, Richmond Foundry and Mfg. Co., Inc.; vice president—A. M. Nutter, treasurer, E. L. LeBaron Foundry Co.; secretary—A. H. Renfrow, partner—general manager, Renfrow Foundry; treasurer—H. J. Trenkamp, president, Ohio Foundry Co.

Investment Casting Institute has announced the election of K. W. Thompson, president of K. W. Thompson Tool Co., as president. New vice president is P. W. Schipper, manager of the Investment Casting Div., Howard Foundry Co.

Federation of Paint and Varnish Production Clubs has installed Milton A. Glasser, Midland Industrial Finishes, as its 35th president.

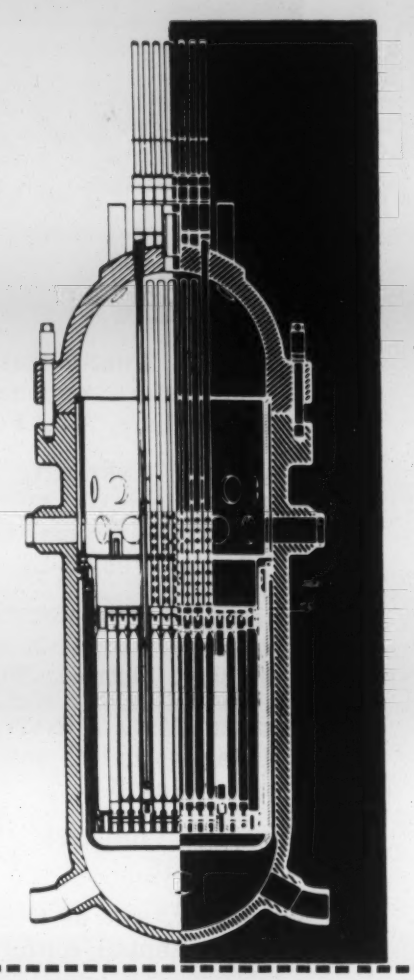
National Screw Machine Products Assn. has appointed Daniel F. Viles, Waltham Screw Co., as chairman of its Technical Research & Standards Committee.

American Society of Mechanical Engineers has installed William F. Ryan as president. Also appointed: Eugene W. Jacobson, Gulf Research and Development Co., technical director, and V. Weaver Smith, Lummus Co., administrative director. In addition, four regional vice presidents have been named: William H. Byrne, Byrne Associates, Inc.; James H. Sams, Clemson College; Holland S. Stoven, R. S. Stover Co.; and Clifford H. Shumaker, Southern Methodist University.

American Die Casting Institute has named Clifford J. Sheehan as president. He is sales manager, Die Casting Div., Aluminum Co. of America.

Aircraft Industries Association of America has elected General Orval R. Cook (USAF, ret.) president. He succeeds Admiral De Witt C. Ramsey (USN, ret.) who was elected vice chairman of the Board of Governors.

(news of Meetings on p 268)

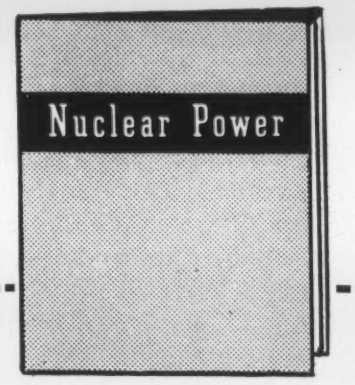


ENGINEERS

Build Your Career Today on the Solid Foundation of the Industry of Tomorrow

ATOMIC POWER

Write today for free, informative booklet, "Nuclear Power"



Mr. John D. Batey, Westinghouse Electric Corp.
Dept. M-14, P.O. Box 1047, Pittsburgh 30, Penna.

Dear Mr. Batey:

Please send me your free booklet entitled "Nuclear Power." I am interested in the field(s) checked below.

- ☐ **ELECTRICAL ENGINEERING**
  - ☐ Pressure Vessels
  - ☐ Stress Analysis
  - ☐ Valves & Pumps
  - ☐ Electro Mechanical Mechanisms
  - ☐ Heat Exchangers
  - ☐ Marine Engineering
  - ☐ Layout & Arrangements
  - ☐ Field Engineering
- ☐ **METALLURGICAL ENGINEERING**
  - ☐ Welding Engineering
  - ☐ Materials
  - ☐ Standards
  - ☐ Heavy Fabrication
  - ☐ Non-destructive Testing
- ☐ **QUALITY CONTROL**
  - ☐ Mechanisms
  - ☐ Pumps & Valves
  - ☐ Non-Destructive Testing
  - ☐ Technical Writing
- ☐ **MANUFACTURING ENGINEERING**
  - ☐ Pressure Vessels
  - ☐ Pumps & Valves
  - ☐ Instrumentation
  - ☐ Piping
  - ☐ Welding
  - ☐ Heavy Fabrication
  - ☐ Machine & Tool Design
  - ☐ Machining & Heat Treating

I have attended the following school(s) _____

_____

I hold the following degree(s) _____

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Westinghouse®
ELECTRIC CORP.
First in Atomic Power

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Non-Contaminating!
Self-Lubricating!

—SPECIFY

morganite

SELF-LUBRICATING

CARBON PISTON RINGS and ROD PACKINGS

. . . for non-lubricated compressors

Eliminates lubrication problems in compressors where contamination cannot be tolerated. The inherent lubricating property of Morganite, plus ability to polish and glaze compensating surfaces, assure friction minimizing operation. A corrosion resistant film imparted to opposing metal surfaces prevents scoring . . . reduces maintenance and replacement.

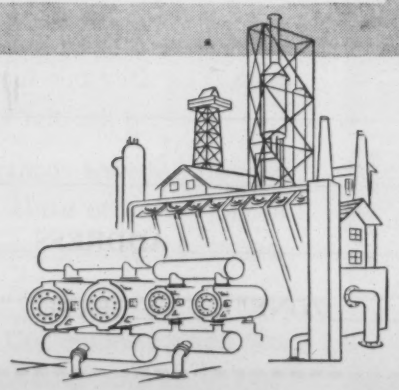
CARBON GLAND RINGS

. . . for high sealing efficiency

For trouble-free operation in turbines, compressors, blowers, fans.

These high efficiency pressure and vacuum seals for steam turbines can be safely mounted with less clearance than metallic rings. Unaffected by axial movement of shaft, accommodate considerable radial shaft displacement with no danger of seizure or loss of efficiency.

Specify Morganite! For sealed mechanisms, inaccessible locations or where contamination is a problem — Morganite Self Lubricating Bearings, Valves, Slides, Seal Noses and Pump Vanes are available. Write for complete details and literature, now!



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. . . FOR OVER HALF A CENTURY

Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

For more information, turn to Reader Service Card, Circle No. 391

News of Industry

Meetings

AMERICAN FOUNDRYMEN'S SOCIETY, Southeastern regional conference. Birmingham, Ala. Feb 21-22.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, annual meeting. New Orleans. Feb 24-28.

SOCIETY OF AUTOMOTIVE ENGINEERS, passenger car, body and materials meeting. Detroit. Mar 5-7.

PRESSED METAL INSTITUTE, annual spring technical meeting. Cleveland. Mar 6-8.

NUCLEAR CONGRESS. Philadelphia. Mar 11-15.

NATIONAL ASSN. OF CORROSION ENGINEERS, annual conference and exhibition. St. Louis. Mar 11-15.

STEEL FOUNDERS' SOCIETY OF AMERICA, annual meeting. Chicago. Mar 18-19.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, regional meeting on drawing-quality steels. Detroit. Mar 18-19.

SOCIETY OF THE PLASTICS INDUSTRY, annual national conference and Pacific Coast plastics exposition. Los Angeles. Mar 18-21.

SOCIETY OF AUTOMOTIVE ENGINEERS, production meeting and forum. Buffalo, N. Y. Mar 20-22.

AMERICAN SOCIETY OF TOOL ENGINEERS, technical meeting and convention. Houston, Tex. Mar 25-27.

AMERICAN SOCIETY FOR METALS, Western metals congress and exposition. Los Angeles. Mar 25-29.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic meeting and production forum, and aircraft engineering display. New York. Apr 2-5.

NATIONAL SCREW MACHINE PRODUCTS ASSN., annual meeting. Washington, D. C. Apr 7-10.

AMERICAN WELDING SOCIETY, national spring technical meeting and Welding Show. Philadelphia. Apr 8-12.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, design engineering conference. New York. May 20-22.

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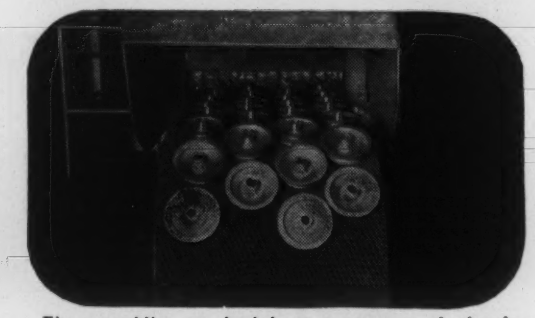

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BOOKS & REPORTS

Books

Chromium, Vol. 2: Metallurgy of Chromium and Its Alloys. *Edited by Marvin J. Udy. ACS Monograph No. 132. Reinhold Publishing Corp., New York 22, N. Y. 1956. Cloth, 9 by 6 in., 410 pp. Price $11.*

The second volume of a two volume monograph on chromium describes the metallurgy of chromium and its alloys. Written by 30 experts in various fields of chromium chemistry, the book is divided into three sections.

Section one deals with the recovery of chromium from its ores and contains information on the electroplating of chromium and the deposition of chromium by methods other than electrolysis. Section two deals with chromium in iron and steel alloys, and alloys containing cobalt, nickel, aluminum, copper and titanium. Section three gives information on chromium in refractories.

The Fatigue of Metals. *The Institution of Metallurgists, 4 Grosvenor Gardens, London, S. W. 1, England. 1956. Cloth, 5½ by 8¾ in., 148 pp.*

This book contains five papers dealing with the general problems of metal fatigue. The papers, given by recognized authorities are: 1) Fundamental Considerations on the Fatigue of Metals; 2) The Effect of Fatigue of Notches, Surface Finishes, Etc.; 3) The Structural Aspects of Aircraft Fatigue; 4) Corrosion Fatigue; and 5) Effect of Temperature on Fatigue Properties. All the papers are fully illustrated and contain a bibliography. Sixteen double-page tables at the end of the book give valuable information on the fatigue properties of magnesium, aluminum, copper, and nonaustenitic and austenitic ferrous alloys at atmospheric and elevated temperatures.

Resins, Rubbers, Plastics Yearbook: 1955. *Edited by H. Mark, E. S. Proskauer and V. J. Frilette. Interscience Publishers, Inc., 250*

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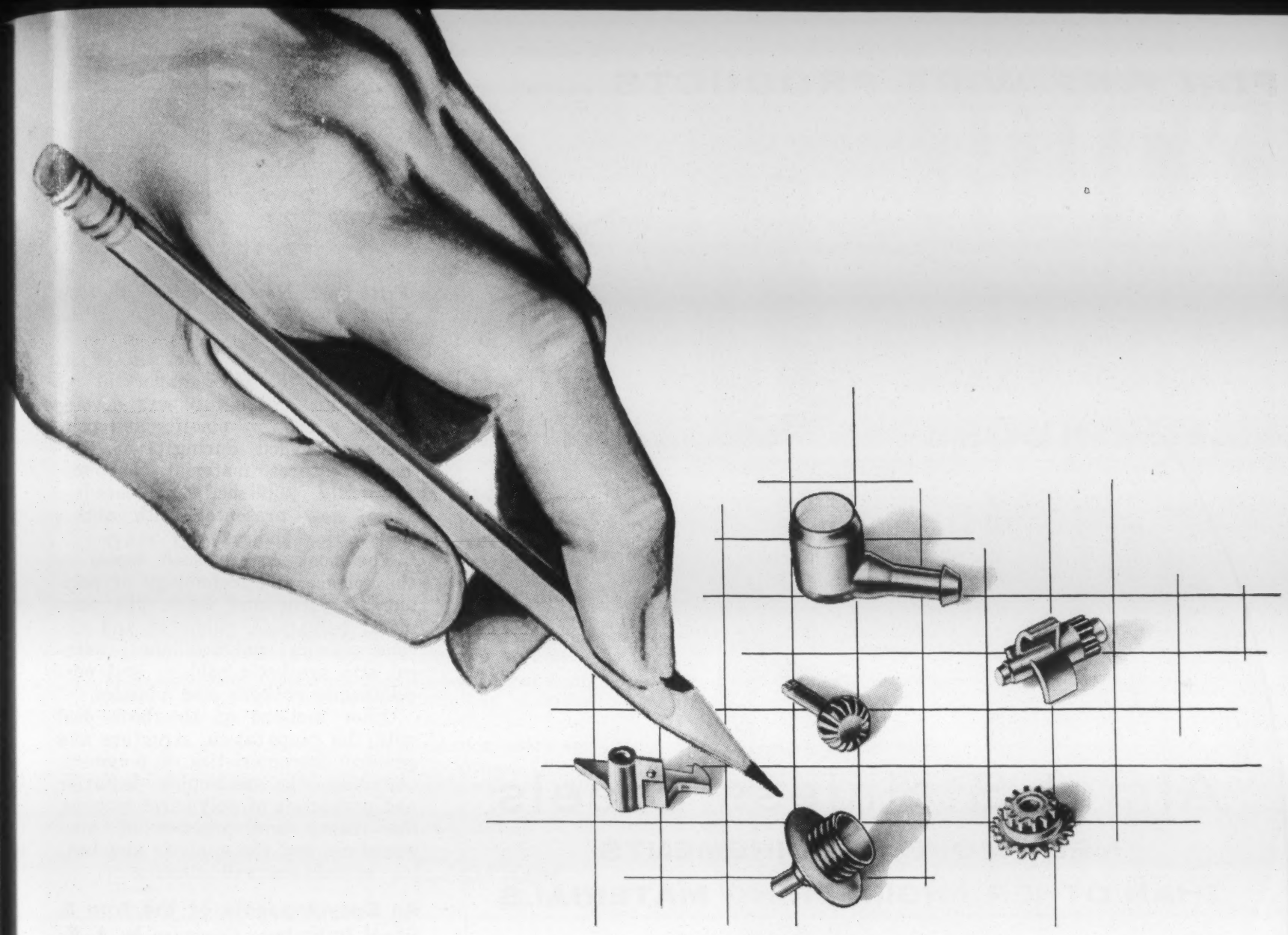

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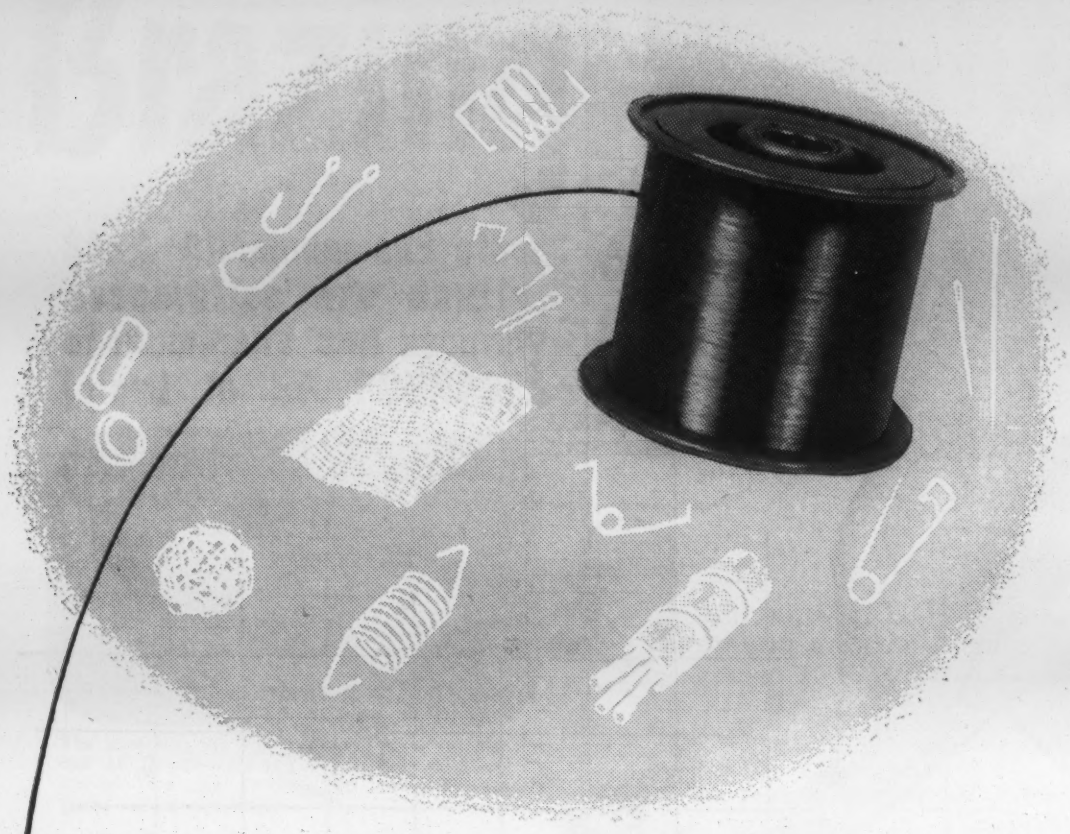

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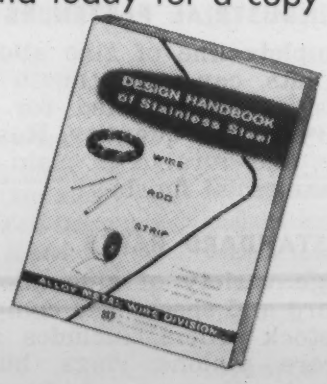

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BOOKS & REPORTS

Fifth Ave., New York 1, N. Y. 1956. Cloth, 6½ by 9¾ in., 1148 pp. Price $35.

This book is a collection of abstracts of the most important domestic and foreign papers devoted to the science of plastics and polymers published during 1955. The book features material that was originally published in loose-leaf form, now presented with author and subject indices.

The book covers such topics as the science and technology of polymers; styrene and vinyl type polymers; polyamide, polyester and silicone plastics; polyurethanes; natural and synthetic rubber; and miscellaneous rubbers and plastics.

Other sections of the book deal with the preparation, structure and general characteristics of polymers, including the molecular behavior and properties of polymeric systems, the theory and practice of compounding, and the analysis and testing of rubbers and plastics.

An Encyclopaedia of the Iron & Steel Industry. *Compiled by A. K. Osborne. Philosophical Library, Inc., New York 16, N. Y. 1956. Cloth, 9½ by 6¼ in., 558 pp. Price $25.*

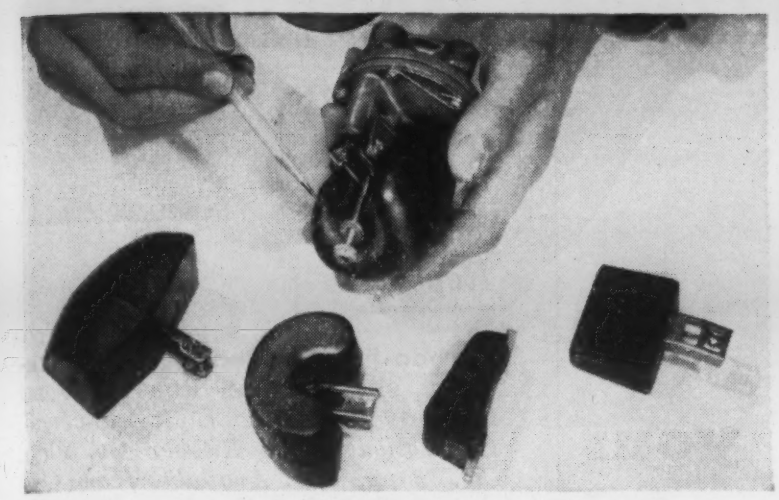
Concise descriptions of the materials, equipment and processes used in the iron and steel industry and allied industries are given in alphabetical order. The easy-to-read, two column pages are illustrated with such things as diagrams showing cross sections of steelmaking equipment, and photos showing microstructures of cast iron and steels.

The encyclopedia gives a complete list of scientific, technical and trade societies. A bibliography, conversion tables and properties of steels are also given.

Stress Corrosion Cracking and Embrittlement. *Edited by William D. Robertson. John Wiley & Sons, Inc., New York 16, N.Y. 1956. Cloth, 6 by 9 in., 210 pp. Price $7.50.*

This volume contains 14 articles dealing with the problem of stress corrosion cracking and embrittlement of ferrous and nonferrous metals. The articles, written by authorities in the field, discuss stress corrosion cracking of mild steels, aluminum alloys, stainless steels and magnesium alloys. Includes an illustrated description of phenomenon and mechanism of stress corrosion cracking.

(Reports on p 274)



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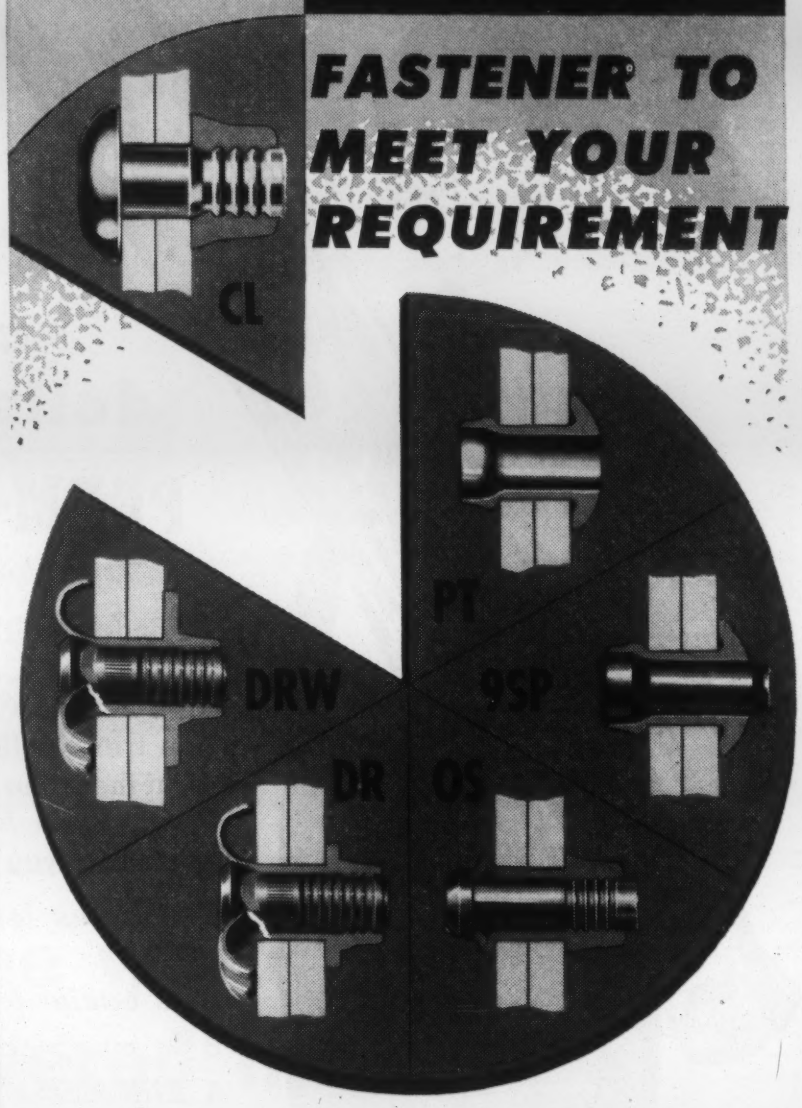

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BOOKS & REPORTS

Reports

Carbon-filled silicone REINFORCEMENT OF SILICONE RUBBER WITH CARBON BLACK. *A. J. deFrancesco, Connecticut Hard Rubber Co. Feb. '56. 33 pp, illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1. (PB 121231)*

A silicone polymer (Linde W-96), when filled with various carbon blacks, was successfully cured to form a firm, well-reinforced rubber. An optimum loading of most acetylene and furnace blacks can be used in silicone rubber, whereas channel blacks severely retard the cure.

Iron-base sheet alloy DEVELOPMENT OF AUSTENITIC IRON-BASE SHEET ALLOY. *R. R. Rothermel, Crucible Steel Co., May '56. 25 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 75¢. (PB 121438)*

Shows satisfactory welding of AD30 sheet alloy, a promising Type II steel. Both metallic arc and butt flashwelding processes were used. Bend tests on a number of specimens show good ductility and short time tensile tests at 1500 F indicate weld strengths comparable to those of the AD30 base material. Prerequisites for successful welding were also determined.

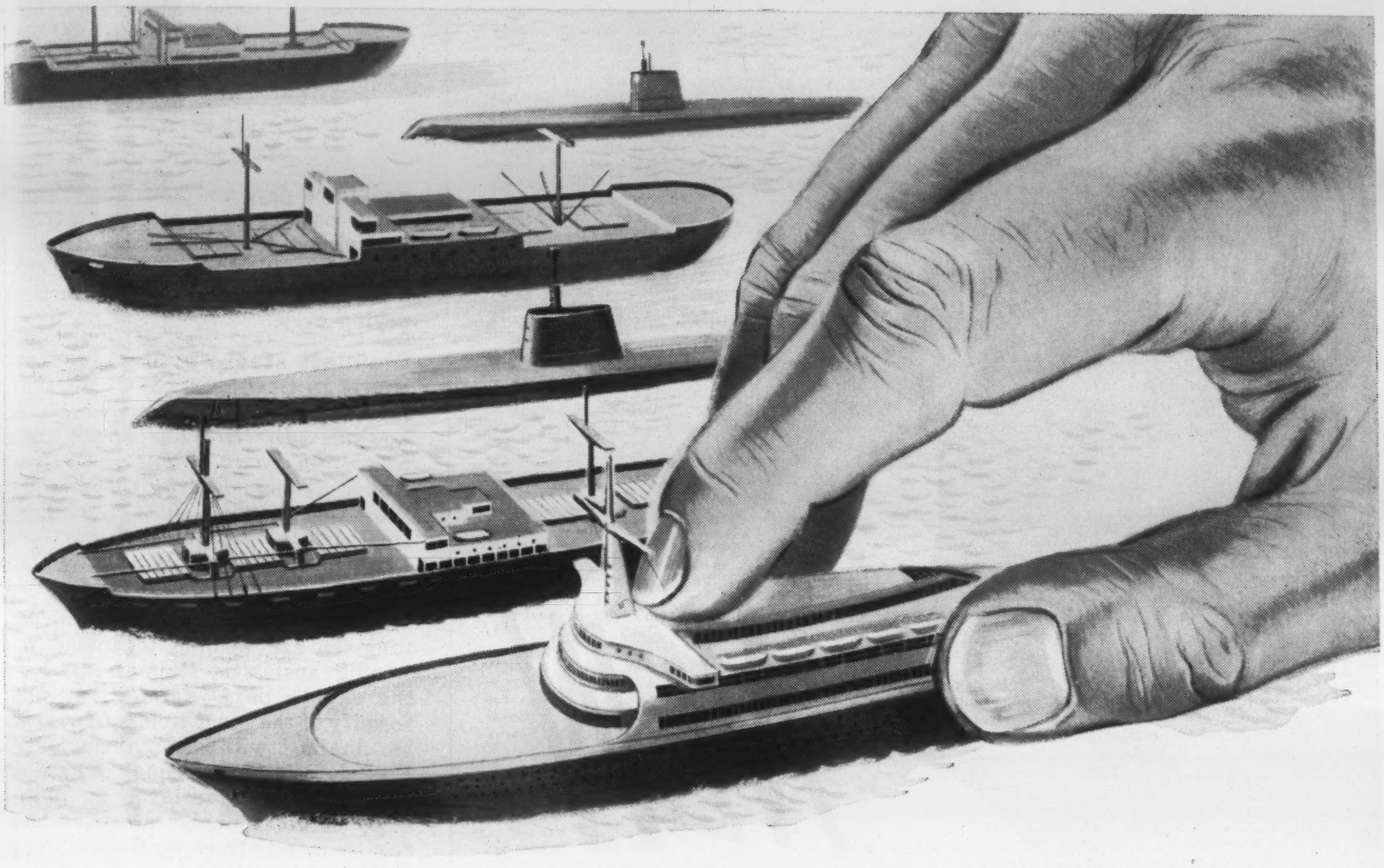
Fatigue of 4340 STATIC FATIGUE IN TWELVE HEATS OF 4340 STEEL EMBRITTLED WITH HYDROGEN. *H. H. Johnson, et al., Case Institute of Technology, Aug '55. 41 pp, illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.25. (PB 121063)*

Twelve heats of AISI 4340 steel exhibited delayed failure over a substantial stress range at 230,000 and 270,000 psi after electrolytic introduction of hydrogen. Failure time increased linearly with increasing charged notch tensile strength. Failure time and charged notch tensile strength decreased with increasing amounts of phosphorus and sulfur.

Acid resistant coating DEVELOPMENT OF A PROTECTIVE COATING RESISTANT TO NITRIC ACID AND HYDROCARBONS. *D. F. Siddall, H. L. Cahn, E. Hillier and M. Gunther, U. S. Stoneware Co. Feb '56. 103 pp, illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $2.75. (PB 121217)*

Fluorocarbon resin X-200, manufactured by M. W. Kellogg Co., resists white fuming nitric acid. Air

METALLURGICAL ENGINEERS...



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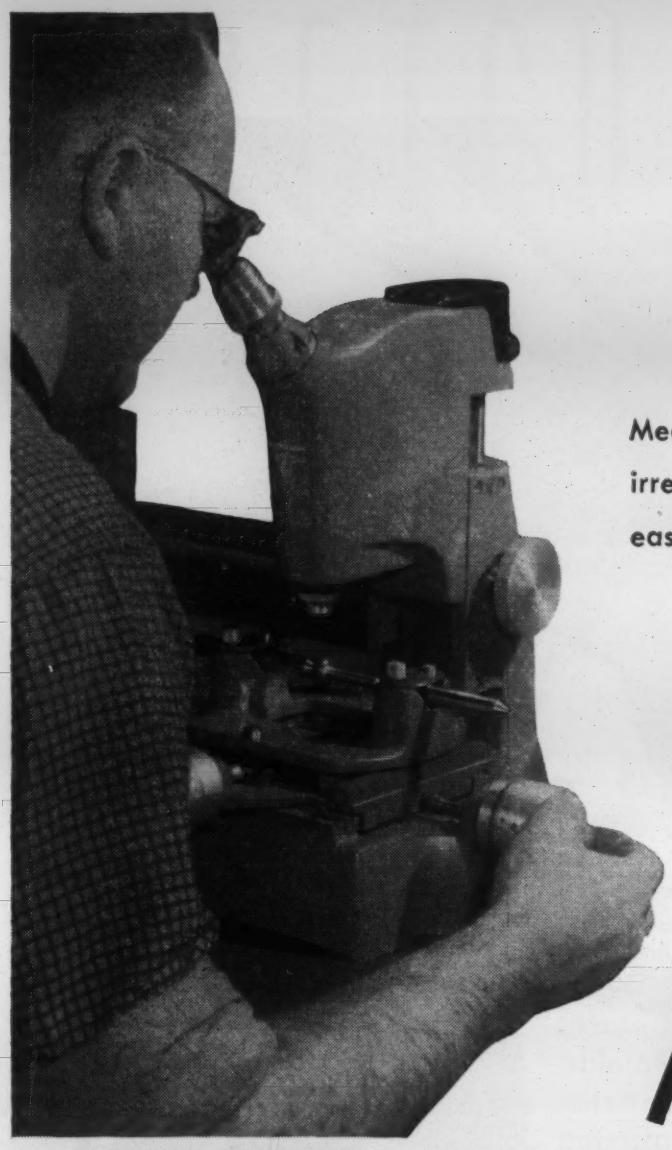

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BOOKS & REPORTS

and force dry, and low temperature bake coatings have been tentatively formulated to provide the required protection. Work is now being conducted to provide a more practical drying cycle.

Stainless steel welding DEVELOPMENTS IN STAINLESS STEEL WELDING IN THE NUCLEAR PROGRAM. *E. B. LaVelle, L. H. Rasmussen and E. M. Kuchera, "The Industrial Atom," Atomic Energy Commission, Aug 1956. 20 pp, illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. (TID-8013)*

Describes an inert-gas-shielded tungsten arc welding technique for joining austenitic stainless steel at the closure pass. Satisfactory uniformity of the inner weld surface can be obtained with comparative ease. Procedure is almost equal in ease of application to those involving placement of consumable inserts, which require merely tracking the arc along the joint.

Paper honeycomb cushioning PERFORMANCE CHARACTERISTICS OF PAPER HONEYCOMB CUSHIONING MATERIALS IMPACTED UNDER A HEAVY WEIGHT HIGH SHOCK MACHINE. *Edward N. Sabbagh, Lowell Technological Institute Research Foundation. Jan 1956. 62 pp, graphs, tables. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.75 (PB 121183)*

Tests show paper honeycomb materials are more efficient energy absorbers at the lower limit of the imposed test conditions than other cushioning materials previously tested. They are much less effective in the higher portions of the test range. A correlation between energy absorption and density is given.

Notch ductility NOTCH DUCTILITY OF MALLEABLE IRONS. *G. A. Sandoz, N. C. Howells, H. F. Bishop and W. S. Pellini, Naval Research Laboratory, May '56, 22 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 75¢. (PB 121033)*

Drop weight tests on malleable irons were conducted to establish nil ductility transition (NDT)—the temperature at which there is a complete loss of ductility in the presence of a sharp, crack-like notch. Explosion tests of plates with crack starter welds also were conducted. Charpy V curves were established for various irons and related to behavior of irons in both the drop weight and explosion tests.

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THE LAST WORD

by ***H. R. Clauser,*** *Editor*

A Slight Twist of the Arm

Materials suppliers, like ourselves, frequently receive requests for information from students. Although they are time consuming to answer, most companies will take care of reasonable requests. But many letters are either too vague or too demanding to permit an answer. We have had student letters asking for "all information on the engineering profession" and for "any and all the data you have on steel."

Recently, a friend in a metal producing company showed us a student letter that was not only of the "any and all" type, but also contained a crude form of blackmail. The letter ended this way: "we are required to include at the end of our paper carbon copies of all letters sent out to the various companies and . . . the replies and literature we receive from each company. If there is no reply we are to simply include a sheet of paper (with) the words 'NO REPLY' typed on it . . . The reason for this is that our instructor, Mr. ————, is very inquisitive as to how big business treats student queries."

If all of this student's letters contain this same arm twisting paragraph, I'm sure the appendix to his paper will be filled with blank pages titled NO REPLY.

Tasty Flaps

The moral of the story you have just read is: when asking someone for help or information, be polite and thoughtful and make it as pleasant as you can for him to answer. We try to live by this rule ourselves, but maybe we try harder than necessary. The other day we received a surprisingly prompt return of one of our current questionaires. The reader had not only filled it out completely and accurately, but he also expressed his gratitude for the opportunity to do so. We were perplexed at such an enthusiastic response until we discovered the note he had written on the back of the return envelope. It said: "Like your flap glue too."

I wonder how much our returns would skyrocket if we flavored the flaps with rye or scotch.

A Low Fi Listens to Hi Fi

I don't suppose I'm telling hi-fi fans anything they don't already know, but for the low-fies, like myself, here is some information about phonograph records that I picked up at a recent meeting of the Society of Plastics Engineers. At present polyvinyl chloride is the best record material. It provides considerably better sound reproduction and better wear life than polystyrene. However, Dow Chemical Co. has just developed a new polystyrene formulation that promises to outperform and outwear the best polyvinyl chloride records. I listened to a demonstration comparing the two record materials, and even my low-fi ears could easily detect the improvement in fidelity obtained with the new polystyrene formulation.